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VOL. XXXI ALBANY, N.Y., 1917, NOVEMBER 24 NO. 1

MEASURES OF DOUBLE STARS,

MADE AT THE LILLE OBSERVATORY AND AT THE ROYAL OBSERVATORY, GREENWICH,

By ROBERT JONCKHEERE.

The present paper is the first of a series bringing together my double star work not already contained in the catalogue recently published as Vol. LXI of the memoirs of the Royal Astronomical Society.

The earlier measures were made with the 14-inch refractor of the Observatory of the University of Lille and the later ones with the 28-inch refractor of the Royal Observatory, Greenwich. A full description of the method of observation will be found in the memoir referred to. The star places are for 1920.

The observing journals being left at Lille, there are a few cases where only the means of several nights are given. All the stars observed with the 14-inch have been remeasured with the 28-inch and there are a number measured with the 28-inch only. For the opportunity of making these later observations, I am greatly indebted to the Astronomer Royal.

70 OΣ 2 $0^{h}\,9^{m}\,15^{s}$ $+26^{\circ}\,32'$

A and *B*

1900 +	θ	ρ	Mags.		Aper.	Rem.
	°	″			in.	
14.904	35.3	0.42	6.0	7.6	28	
14.967	37.0	0.43	6.0	7.5	28	
14.991	29.0	0.46	6.0	8.2	28	
14.95	33.8	0.44	6.0	7.8	3*n*	(1)

AB and *C*

14.904	224.4	18.30	..	9.7	28	
14.967	224.2	17.85	..	9.5	28	
14.991	224.5	18.09	..	10.0	28	
14.95	224.4	18.08	..	9.7	3*n*	

235 *h* 1976 $0^{h}\,25^{m}\,30^{s}$ $+19^{\circ}\,51'$

AB and *C*

10.773	262.6	12.93	.	11.0	14	
10.779	263.0	12.22	.	10.5	14	
14.904	263.8	12.75	.	11.0	28	
16.895	262.2	12.33	.	11.8	28	
13.36	262.9	12.56		11.1	4*n*	(2)

AB = *J* 168

1900 +	θ	ρ	Mags.		Aper.	Rem.
	°	″			in.	
10.773	169.0	0.82	9.0	9.0	14	
10.779	173.5	0.91	9.0	9.0	14	
10.784	174.0	0.73	9.0	9.0	14	
13.450	166.3	0.92	9.0	9.0	14	(3)
14.904	165.6	1.08	8.9	8.9	28	
16.895	173.2	1.24	9.3	9.3	28	
13.00	169.7	0.95	9.0	9.0	7*n*	

426 Σ 60 $0^{h}\,44^{m}\,0^{s}$ $+57^{\circ}\,24'$

15.608	249.5	6.78	4.0	8.0	28	
15.613	249.2	6.94	3.5	8.0	28	
15.61	249.4	6.86	3.7	8.0	2*n*	(4)

131 *β* 495 $0^{h}\,44^{m}\,31^{s}$ $+18^{\circ}\,15'$

14.904	214.0	0.60	6.0	7.0	28	
14.991	214.0	0.84	7.0	7.4	28	
14.95	214.0	0.72	6.5	7.2	2*n*	(5)

179 OΣ 20 $0^{h}\,50^{m}\,21^{s}$ $+18^{\circ}\,45'$

14.904	300.4	0.41	6.0	7.0	28	(6)
14.920	300.4	0.30	6.5	6.5	28	(7)
14.91	300.4	0.37	6.2	6.7	2*n*	(8)

182 Σ 73 $0^{h}\ 50^{m}\ 40^{s}$ +23° 12′

1900 +	θ °	ρ ″	Mags.		Aper. in.	Rem.
09.812	33.8	1.07	6.5	6.6	14	
09.815	30.2	1.25	7.0	7.0	14	
09.829	32.7	0.95	6.8	7.0	14	
10.855	32.5	0.94	7.0	7.0	14	
10.973	31.2	1.00	7.5	7.5	14	
14.835	42.2	1.00	6.0	6.0	28	
14.862	34.8	0.97	6.0	6.0	28	
10.26	32.1	1.04	7.0	7.0	$5n$	
14.85	38.5	0.99	6.0	6.0	$2n$	
16.03	40.4	0.89	6.0	6.0	$1n$	(9)

508 β 302 $0^{h}\ 54^{m}\ 2^{s}$ +20° 58′

09.812	103.6	0.60	6.8	6.8	14	
09.951	105.6	0.60	6.8	7.5	14	
09.958	104.7	0.66	6.0	7.6	14	
10.829	108.0	0.65	6.8	8.0	14	
10.987	104.4	0.50	7.0	8.5	14	
14.819	110.2	0.66	6.5	9.0	28	
14.821	112.2	0.63	6.0	8.0	28	
14.830	110.8	0.67	6.0	7.5	28	
09.91	104.6	0.62	6.5	7.3	$3n$	
10.91	106.2	0.57	6.9	8.2	$2n$	
14.82	111.1	0.65	6.2	8.2	$3n$	(10)

612 β 303 $1^{h}\ 5^{m}\ 19^{s}$ +23° 22′

14.904	281.4	0.48	7.0	7.0	28	
14.920	283.0	0.52	7.0	7.0	28	
14.91	282.2	0.50	7.0	7.0	$2n$	(11)

707 Σ 113 $1^{h}\ 16^{m}\ 7^{s}$ −0° 55′

09.812	354.0	1.38	6.0	7.0	14	
09.815	357.2	1.10	6.6	7.0	14	
09.837	359.7	1.50	6.5	7.5	14	
14.835	360.4	1.23	6.8	7.2	28	
14.862	360.4	1.35	6.0	6.8	28	
09.82	357.0	1.43	6.4	7.2	$3n$	
14.85	360.4	1.29	6.4	7.0	$2n$	(12)

830 Σ 138 $1^{h}\ 31^{m}\ 51^{s}$ +7° 15′

09.812	42.2	1.35	7.0	7.0	14	
09.815	39.4	1.25	7.5	7.5	14	
09.837	39.6	1.52	7.5	7.5	14	
14.835	40.2	1.54	6.8	7.0	28	
14.862	40.2	1.21		. .	28	
09.82	40.4	1.37	7.3	7.3	$3n$	
14.85	40.2	1.38	6.8	7.0	$2n$	(13)

851 β 5 $1^{h}\ 34^{m}\ 56^{s}$ +16° 13′

1900 +	θ °	ρ ″	Mags.		Aper. in.	Rem.
09.812	291.4	1.48	7.0	9.0	14	
09.845	293.0	1.30	7.0	10.2	14	
09.848	290.6	1.54	7.0	10.4	14	
14.835	291.8	1.10	6.9	9.5	28	
14.862	287.8	0.90	6.5	9.0	28	
11.84	290.9	1.26	6.9	9.6	$5n$	(14)

946 β 510 $1^{h}\ 14^{m}\ 13^{s}$ +15° 56′

14.819	329.0	1.70	9.0	11.5	28	
14.821	328.6	1.66	8.8	11.5	28	
14.82	328.8	1.68	8.9	11.5	$2n$	(15)

977 Ho 311 $1^{h}\ 45^{m}\ 45^{s}$ +24° 15′

14.904	187.6	0.38	. .	. . .	28	
14.920	190.0	0.35	7.0	7.0	28	
14.91	188.8	0.37	7.0	7.0	$2n$	(16)

993 Σ 180 $1^{h}\ 48^{m}\ 7^{s}$ +18° 54′

14.906	358.0	8.20	4.5	4.5	28	
14.920	359.4	8.32	4.0	4.0	28	
14.91	358.7	8.26	4.3	4.3	$2n$	(17)

1002 Σ 183 $1^{h}\ 50^{m}\ 32^{s}$ +28° 25′

A and *B*

14.904	357.0	0.30	7.0	7.0	28	(18)
14.920	350.0	0.40	7.0	7.0	28	(19)
14.91	353.5	0.35	7.0	7.0	$2n$	

AB and *C*

14.904	165.0	5.61	. .	8.4	28	(20)

1015 Σ 186 $1^{h}\ 51^{m}\ 44^{s}$ +1° 27′

09.812	37.0	0.85	7.0	7.0	14	
09.815	36.4	0.73	7.0	7.0	14	
09.845	36.8	0.63	7.0	7.0	14	
11.075	35.2	0.98	7.0	7.0	14	
11.080	33.2	1.13	6.9	6.9	14	
11.083	33.6	1.12	6.9	6.9	14	
14.835	35.4	0.75	7.1	7.0	28	
14.862	35.8	0.88	6.0	6.0	28	
09.82	36.7	0.74	7.0	7.0	$3n$	
11.08	34.0	1.08	6.9	6.9	$3n$	
12.07	36.9	1.05	7.2	7.2	$2n$	
14.85	35.6	0.82	6.6	6.5	$2n$	(21)

1070 OΣ 38 1h 58m 58s +41° 57′

B and *C*

1900 +	θ °	ρ ″	Mags.		Aper. in.	Rem.
09.812	117.4	0.38	5.0	6.0	14	
09.815	118.4	0.32	5.6	6.3	14	
09.837	115.0	0.34	5.0	6.0	14	
09.845	108.8	0.30	5.2	6.2	14	
11.083	111.2	0.39	5.5	6.5	14	
11.130	112.5	0.38	..	..	14	
15.115	107.6	0.50	..	..	28	
16.019	113.6	0.46	6.0	7.0	28	
09.83	114.9	0.34	5.2	6.1	4*n*	
11.11	111.9	0.39	5.5	6.5	2*n*	
15.57	110.6	0.48	6.0	7.0	2*n*	(22)

A and *BC* = Σ 205

09.812	63.5	10.35	2.9	..	14	
09.815	62.1	10.20	2.0	..	14	
09.837	62.6	10.25	2.0	..	14	
11.083	63.1	10.08	2.5	..	14	
11.130	64.0	9.98	..	..	14	
15.115	63.4	10.49	..	..	28	
16.019	64.0	10.85	2.5	..	28	
11.83	63.2	10.31	2.4	..	7*n*	(23)

1071 Σ 208 1h 59m 5s +25° 33′

14.873	104.8	0.20	..	...	28	
14.879	102.4	0.20	6.0	8.0	28	
12.06	89.0	0.39	6.8	7.8	1*n*	
14.88	103.6	0.20	6.0	8.0	2*n*	(24)

1105 Σ 214 2h 3m 18s +15° 12′

14.920	187.1	4.92	8.0	10.0	28	
14.991	193.2	5.57	8.2	9.5	28	
14.96	190.1	5.25	8.1	9.8	2*n*	(25)

1120 Σ 221 2h 4m 15s +19° 58′

14.920	144.6	8.66	7.5	9.2	28	
14.991	145.5	8.84	7.5	9.2	28	
14.96	145.1	8.75	7.5	9.2	2*n*	(26)

1278 Σ 269 2h 24m 6s +29° 34′

14.873	344.5	1.45	7.8	9.0	28	
14.904	345.2	1.83	7.0	9.5	28	
15.148	345.6	1.65	..	...	28	
14.97	345.1	1.64	7.4	9.3	3*n*	(27)

1127 Σ 305 2h 42m 56s +19° 3′

1127 Σ 305 2h 42m 56s +19° 3′ — *Continued.*

1900 +	θ °	ρ ″	Mags.		Aper. in.	Rem.
11.037	316.2	3.25	7.5	8.5	14	
11.045	314.2	2.90	7.7	8.2	14	
14.835	312.2	2.98	7.5	8.5	28	
14.862	311.6	2.98	6.5	7.5	28	
11.04	315.2	3.08	7.6	8.4	2*n*	
14.85	312.1	2.98	7.0	8.0	2*n*	(28)

1512 Σ 333 2h 51m 38s +21° 2′

09.812	202.4	1.27	5.8	6.0	14	
09.815	203.0	1.32	6.0	7.0	14	
09.837	203.0	1.19	6.0	6.8	14	
11.037	198.7	1.52	6.0	6.2	14	
11.045	200.8	1.45	5.5	5.9	14	
11.086	199.8	1.53	6.0	7.0	14	
11.108	198.7	1.42	5.8	6.0	14	
12.091	199.4	1.43	6.0	6.3	14	
14.835	201.8	1.51	6.0	6.2	28	
14.862	202.4	1.12	6.0	6.5	28	
14.920	200.8	1.47	6.0	6.0	28	
11.86	200.9	1.38	5.9	6.4	11*n*	(29)

1559 Σ 346 3h 0m 44s +24° 57′

A and *B*

14.835	278.6	0.30	7.0	7.0	28	
14.873	263.4	0.30	7.0	7.0	28	
14.904	263.2	0.35	6.0	7.0	28	
14.87	268.4	0.32	6.7	7.0	3*n*	(30)

AB and *C*

14.835	355.8	4.95	..	9.8	28	
14.873	355.0	4.80	..	10.0	28	
14.904	356.3	4.95	..	9.0	28	
14.87	355.7	4.90	..	9.6	3*n*	

1563 Σ 350 3h 2m 58s +40° 39′

14.879	117.9	16.75	9.0	10.5	28	
14.920	118.6	16.06	8.0	10.0	28	
14.90	118.3	16.41	8.5	10.3	2*n*	(31)

1683 Σ 381 3h 18m 42s +20° 42′

09.812	92.0	0.88	7.5	8.2	14	
09.815	95.6	0.78	7.0	8.0	14	
09.845	97.8	0.97	7.6	9.2	14	
14.873	107.0	0.76	7.0	9.0	28	
14.879	105.2	0.60	7.0	9.2	28	
11.84	99.5	0.80	7.2	8.7	5*n*	(32)

1799 Σ 425 3h 35m 4s +33° 52′

14.879	89.6	2.57	8.0	8.0	28	
14.904	99.6	2.53	..	...	28	
14.967	99.0	2.57	7.0	7.0	28	
14.92	96.1	2.56	7.5	7.5	3*n*	(33)

1818 Σ 431 3^{h} 37^{m} 17 +33° 43′

1900 +	θ	ρ	Mags.		Aper. in.	Rem
14.879	237.1	20.02	5.0	8.0	28	
15.148	238.2	20.38	5.0	9.0	28	
15.241	237.6	20.26	4.0	9.0	28	
15.09	237.6	20.22	4.7	8.7	3*n*	(34)

1831 β 535 3^{h} 39^{m} 16^{s} +32° 2′

14.835	49.2	0.58	5.0	8.0	28	
14.873	52.2	0.48	6.0	9.0	28	
14.879	44.4	0.63	5.0	10.0	28	
14.86	48.6	0.56	5.3	9.0	3*n*	(35)

1835 Ho 504 3^{h} 39^{m} 25^{s} +35° 36′

11.043	190.0	1.19	8.4	8.7	14	(36)
16.153	190.6	1.24	8.0	8.0	28	
12.75	190.2	1.21	8.2	8.5	3*n*	(37)

2007 Σ 483 3^{h} 58^{m} 42^{s} +39° 18′

14.873	188.4	0.48	7.0	9.5	28	
14.879	183.0	0.60	7.0	9.5	28	
14.88	185.7	0.54	7.0	9.5	2*n*	(38)

2093 OΣ 77 4^{h} 10^{m} 53^{s} +31° 32′

11.083	206.2	0.29	8.0	8.0	14	(39)
11.127	215.0	0.28	7.8	7.8	14	(39)
16.153	227.8	0.38	7.8	7.8	28	(40)
17.241	233.8	0.39	7.8	7.8	28	(40)
17.252	234.8	0.36	7.5	7.5	28	(40)
11.10	210.6	0.29	7.9	7.9	2*n*	
16.88	232.1	0.38	7.7	7.7	3*n*	(41)

2270 OΣ 86 4^{h} 31^{m} 53^{s} +19° 36′

14.873	53.2	0.39	7.0	7.0	28	
14.879	51.4	0.48	8.0	8.0	28	
14.88	52.3	0.44	7.5	7.5	2*n*	(42)

2509 OΣ 95 5^{h} 0^{m} 49 +19° 42′

09.815	328.8	0.83	7.0	7.2	14	
09.950	327.4	0.75	7.0	7.5	14	
09.979	328.2	0.80	7.0	8.0	14	
11.037	325.2	0.76	7.0	7.5	14	
11.039	326.0	0.98	6.8	7.2	14	
16.153	322.8	0.87	6.0	6.5	28	
17.241	321.0	0.79	7.0	7.6	28	
09.91	328.1	0.79	7.0	7.6	3*n*	
11.04	325.6	0.87	6.9	7.4	2*n*	
12.12	324.6	0.95	7.0	7.2	2*n*	
16.70	321.9	0.83	6.5	7.1	2*n*	(43)

2815 Σ 749 5^{h} 32^{m} 8^{s} +26° 53′

1900 +	θ °	ρ ″	Mags.		Aper. in.	Rem.
09.982	349.6	0.87	7.2	7.2	14	
11.086	345.9	0.97	6.5	6.5	14	
11.108	344.1	0.90	6.8	6.8	14	
12.132	349.9	1.10	6.9	6.9	14	(44)
15.263	344.6	1.12			28	
16.153	346.1	1.06	6.0	6.0	28	
17.241	349.2	0.99	6.4	6.4	28	
11.43	348.2	1.00	6.9	6.9	6*n*	
16.22	346.7	1.06	6.2	6.2	3*n*	

3382 Σ 910 6^{h} 22^{m} 39^{s} +0° 30′

12.069	165.0	0.44	8.4	8.4	14	
15.115	162.4	0.69	8.5	9.0	28	
17.241	165.4	0.60	8.0	8.2	28	
14.81	164.3	0.58	8.3	8.5	3*n*	(45)

3596 *Sirius* 6^{h} 41^{m} 40^{s} −16° 35′

11.039	86.4	8.68	..	9.6	14	
11.075	87.0	8.67	.	9.5	14	
11.080	87.3	8.92	..	10.0	14	
11.204	87.6	8.75		10.0	14	
13.250	81.4	9.23	.	11.5	14	
13.258	81.8	9.22	.	10.5	14	
14.245	80.6	10.12	.	11.0	14	
14.931	77.6	9.49	.	11.0	28	
14.939	79.2	10.02	.	10.0	28	
14.956	78.5	..		...	28	
15.011	80.0	9.77		10.0	28	
15.016	77.1	10.13		11.5	28	
15.019	79.0	10.61		11.5	28	
15.090	80.6	..	.	11.5	28	
15.115	78.1	9.76		9.3	28	
15.115	78.4	9.77	..	9.9	28	
15.148	79.4	..	..	11.0	28	
16.019	75.6	10.91	..	10.5	28	
16.058	76.4	10.36	..	10.0	28	
16.063	75.7	10.82		11.0	28	
16.096	71.2	10.31	..	11.5	28	
16.162	74.0	10.66	.	9.5	28	
16.246	72.6	10.34		11.2	28	
17.216	74.4	10.59		9.3	28	
17.241	73.6	10.76		9.1	28	
17.252	73.8	10.47	.	9.8	28	
11.10	87.1	8.76	..	9.8	4*n*	
13.25	81.6	9.23	..	11.0	2*n*	
14.77	79.0	9.88	.	10.7	4*n*	
15.07	78.9	10.01	..	10.7	6*n*	
16.11	74.6	10.57	.	10.6	6*n*	
17.23	73.9	10.61		9.4	3*n*	(46)

3692 Σ 982 $6^{h}\,50^{m}\,7^{s}$ $+13^{\circ}\,17'$

1900 +	θ	ρ	Mags.		Aper.	Rem.
	°	″			in.	
15.137	156.4	6.75	6.0	8.0	28	
15.148	159.0	6.51	4.0	6.0	28	
15.14	157.7	6.63	5.0	7.0	2*n*	(47)

3710 Σ 991 $6^{h}\,52^{m}\,7^{s}$ $+25^{\circ}\,4'$

1900 +	θ	ρ	Mags.		Aper.	Rem.
15.022	168.4	3.85	8.0	9.0	28	
15.025	164.4	3.88	8.5	8.9	28	
15.02	166.4	3.87	8.3	9.0	2*n*	(48)

3876 Σ 1037 $7^{h}\,7^{m}\,50^{s}$ $+27^{\circ}\,22'$

1900 +	θ	ρ	Mags.		Aper.	Rem.
15.052	277.0	0.30	6.0	7.0	1*n*	
16.320	268.4	0.30	7.0	7.0	1*n*	
17.241	254.8	0.28	7.2	7.2	1*n*	(49)

3949 OΣ 170 $7^{h}\,13^{m}\,16^{s}$ $+9^{\circ}\,26'$

1900 +	θ	ρ	Mags.		Aper.	Rem.
11.195	107.6	1.56	7.0	7.0	14	
16.320	107.8	1.51	7.5	7.5	28	
16.323	108.0	1.41	7.0	7.0	28	
17.241	106.2	1.54	7.8	7.8	28	
15.27	107.4	1.50	7.3	7.3	4*n*	(50)

3990 Σ 1074 $7^{h}\,16^{m}\,24^{s}$ $+0^{\circ}\,34'$

1900 +	θ	ρ	Mags.		Aper.	Rem.
13.250	145.5	0.65	7.8	7.8	14	
16.323	152.2	0.57	7.0	7.0	28	
17.241	148.8	0.57	8.0	8.0	28	
15.50	148.8	0.60	7.6	7.6	3*n*	(51)

4187 *Procyon* $7^{h}\,35^{m}\,7^{s}$ $+5^{\circ}\,26'$

1900 +	θ	ρ	Mags.		Aper.	Rem.
11.039	22.3	4.55	. .	9.5	14	
11.080	35.0	4.84	. .	9.4	14	
14.939	27.5	5.25	. .	11.5	28	
17.241	47.4	4.12	. .	11.0	28	(52)

4188 Bird 2 $7^{h}\,35^{m}\,30^{s}$ $+5^{\circ}\,27'$

1900 +	θ	ρ	Mags.		Aper.	Rem.
15.052	0.0	0.60	. .	. . .	28	
15.107	5.0	0.50	8.8	8.8	28	
17.241	11.6	0.72	8.8	8.8	28	
15.80	5.5	0.61	8.8	8.8	3*n*	(53)

1193 Σ 1126 $7^{h}\,35^{m}\,51^{s}$ $+5^{\circ}\,25'$

1900 +	θ	ρ	Mags.		Aper.	Rem.
15.107	152.0	1.32	7.5	8.0	28	
15.307	143.6	1.02	8.0	8.0	28	
17.241	152.2	1.12	7.0	7.4	28	
15.89	149.3	1.15	7.5	8.0	3*n*	(54)

1177 Σ 1196 $8^{h}\,7^{m}\,38^{s}$ $+17^{\circ}\,54'$

A and *B*

1900 +	θ	ρ	Mags.		Aper.	Rem.
	°	″			in.	
13.258	316.8	1.02	6.0	6.2	14	
13.269	317.4	1.05	5.7	6.0	11	
15.093	305.0	1.11	5.0	5.0	28	
15.246	314.0	1.11	.	. . .	28	
15.353	306.8	1.03	5.7	5.5	28	
16.315	297.6	0.81	5.5	5.5	28	
16.323	307.0	0.72	5.0	5.0	28	
17.241	297.4	0.84	6.0	6.3	28	
17.271	297.4	0.70	5.5	6.0	28	
11.23	326.2	1.08	5.0	5.7	2*n*	
12.13	323.8	1.05	5.5	5.9	2*n*	
13.26	317.1	1.04	5.8	6.1	2*n*	
15.23	308.6	1.08	5.4	5.3	3*n*	
16.32	302.3	0.77	5.3	5.3	2*n*	
17.26	297.4	0.77	5.7	6.1	2*n*	(55)

AB and *C*

1900 +	θ	ρ	Mags.		Aper.	Rem.
15.093	114.2	5.06	. .	5.0	28	
15.353	113.8	5.69	. .	6.0	28	
16.315	111.0	5.63	. .	5.8	28	
16.323	115.2	5.64	. .	6.0	28	
17.241	113.0	5.73	. .	6.3	28	
17.271	113.0	5.64	. .	6.0	28	
11.23	109.5	5.16	. .	5.7	2*n*	
12.13	110.2	4.98	. .	6.2	2*n*	
15.26	114.0	5.38	. .	6.0	2*n*	
16.32	113.1	5.64	. .	5.9	2*n*	
17.26	113.0	5.68	. .	6.1	2*n*	

4771 Σ 1273 $8^{h}\,42^{m}\,33^{s}$ $+6^{\circ}\,43'$

A and *B*

1900 +	θ	ρ	Mags.		Aper.	Rem.
15.296	310.8	0.18	4.0	4.0	28	
15.307	300.2	0.14	4.0	4.0	28	
15.318	307.4	0.1 ±	4.0	4.0	28	
12.14	219.9	0.23	4.0	7.0	2*n*	
15.31	306.1	0.14	4.0	4.0	3*n*	
16.32	Uncertain (good night)				1*n*	
17.24	Uncertain (very good definition)				1*n*	(56)

AB and *C*

1900 +	θ	ρ	Mags.		Aper.	Rem.
15.115	243.0	3.10	3.0	6.0	28	
15.296	245.0	3.17	3.0	8.5	28	
15.307	244.2	3.49	3.0	7.5	28	
15.318	241.8	3.44	3.0	8.5	28	
15.353	242.8	3.20	. .	. . .	28	
16.323	241.6	2.95	4.4	8.5	28	
17.241	242.2	3.22	3.0	8.0	28	
12.14	238.2	2.89	. .	8.0	2*n*	
15.71	242.9	3.22	3.2	7.8	7*n*	

5005 Σ 3121 9h 13m 10s +28° 55′

1900 +	θ	ρ	Mags.		Aper.	Rem.
	°	″			in.	
13.231	194.2	0.45	8.0	8.0	11	
13.250	209.7	0.40	8.1	8.1	14	
15.307	200.8	0.43	7.5	7.5	28	
15.318	218.8	0.42	7.5	7.5	28	
16.315	211.6	0.42	7.0	7.5	28	
16.323	218.1	0.45	7.5	7.5	28	
17.241	217.4	0.34	7.7	7.7	28	
17.290	211.8	0.42	7.6	7.8	28	
13.24	202.0	0.43	8.0	8.0	2*n*	
15.31	209.8	0.43	7.5	7.5	2*n*	
16.32	216.5	0.43	7.3	7.5	2*n*	
17.27	214.6	0.38	7.7	7.8	2*n*	(57)

5103 Σ 1356 9h 24m 10s +9° 24′

11.283	122.4	1.06	6.5	7.0	14	(58)
12.127	122.0	1.05	6.7	7.6	14	
13.234	123.0	1.18	7.3	7.5	14	
13.250	123.6	1.12	7.7	7.7	11	
15.301	125.0	0.97	6.0	7.6	28	
15.318	125.2	0.76	6.0	7.0	28	
17.241	129.6	1.03	5.0	6.0	28	
17.271	130.6	0.70	6.0	6.5	28	
11.56	122.3	1.06	6.5	7.2	3*n*	
13.24	123.3	1.15	7.5	7.6	2*n*	
15.31	125.1	0.87	6.0	7.3	2*n*	
17.26	130.1	0.87	5.5	6.3	2*n*	(59)

5365 OΣ 215 10h 11m 55s +18° 8′

11.244	202.2	1.06	7.0	7.0	14	(60)
12.127	202.6	1.30	7.0	7.7	14	
15.301	199.8	0.90	6.5	8.0	28	
15.318	202.8	0.92	6.5	6.5	28	
13.05	201.9	1.05	6.8	7.3	5*n*	(61)

5388 Σ 1424 10h 15m 32s +20° 15′

15.353	118.4	3.98	3.0	4.0	28	
17.271	119.4	4.04	2.0	4.8	28	
11.30	115.7	3.66	2.0	4.1	2*n*	
16.31	118.9	4.01	2.5	4.8	2*n*	

5707 Σ 1517 11h 9m 31s +20° 34′

15.323	259.0	0.33	7.0	7.0	28	(62)
16.315	269.1	0.21	7.0	7.0	28	(63)
17.211	242.6	0.28	7.3	7.3	28	(63)
16.29	257.0	0.27	7.1	7.1	3*n*	

5731 Σ 1523 11h 13m 58s +31° 59′

1900 +	θ	ρ	Mags.		Aper.	Rem.
		″			in.	
15.122	113.3	2.98	4.0	5.0	28	
15.411	116.1	3.29	4.0	5.0	28	
17.271	112.8	3.50	5.0	6.0	28	
17.290	111.8	3.14	5.5	6.3	28	
11.33	120.9	3.22	4.0	4.3	2*n*	
15.43	114.7	3.15	4.0	5.0	2*n*	
17.28	112.3	3.32	5.2	6.1	2*n*	(64)

5739 Σ 1527 11h 14m 49s +11° 13′

15.422	19.9	3.32	7.0	8.0	28	
16.315	16.0	4.04	7.0	8.4	28	
17.271	16.2	3.70	7.0	8.0	28	
16.34	17.4	3.69	7.0	8.1	3*n*	(65)

5765 Σ 1536 11h 19m 45s +11° 0′

11.323	40.9	2.06	4.0	7.0	14	(66)
12.127	47.4	2.30	4.0	8.0	14	
15.301	37.2	1.81	4.0	8.5	28	
15.422	41.5	2.03	5.0	8.5	28	
16.315	38.0	2.04	3.8	9.0	28	
17.271	45.0	1.89	5.0	8.5	28	
13.80	41.5	2.03	4.2	8.0	8*n*	

5811 Σ 1555 11h 32m 12s +28° 14′

15.301	11.0	0.30	7.0	7.0	28	
15.416	2.5	0.20	. .	. .	28	
16.315	20.6	0.21	7.4	7.4	28	
17.241	7.4	0.20	7.0	7.0	28	
16.07	10.4	0.23	7.1	7.1	1*n*	(67)

REMARKS

(1) Slow retrograde motion. 10° in the last 40 years.

(2) These are the only measures since Sir JOHN HERSCHEL who gave:

1830 + 263°.5 12″±

(3) A mean of two nights.

(4) These two observations are means of seven sets of measures taken on two nights with dark and bright field and powers from 450 to 1120.

Comparison with LOHSE's orbit gives: (O — C)

1915.61 −1°.9 +0″.07

(5) Since discovery the angle has steadily decreased about 0°.5 a year.

(6) Just separated. The faint star is certainly preceding.

(7) Only elongated.

(8) The motion is not yet clear. It was more rapid in the first quadrant than at present and this is opposed to GLASENAPP's orbit.

(9) The direct and almost uniform motion of 1° a year observed since 1850 continues to the present day, but if BOWYER's orbit is correct, as it seems, the pair will soon become more rapid.

(10) Angle increasing steadily about 0°.5 a year since discovery, although these later measures by themselves would suggest quicker motion.

(11) Without apparent motion.

(12) With regard to this pair, too much weight has previously been given to AUWER's proper-motion of 0″.015 in 277°.6. See *β. G. C.* page 297.

The more recent determination by Boss is altogether different:

AUWERS, −″.015 in *R.A.* and −″.002 in *N.P.D.*
Boss, +″.008 in *R.A.* and −″.009 in *N.P.D.*

This last P.M. is at right angles to the relative motion observed. It is evidently a very slow binary.

(13) Increase no greater than 0°.25 a year.

(14) Probably without change. In 1914 I found the pair rather difficult on account of bad definition.

(15) There may be very slow retrograde motion but it is doubtful.

(16) These measures make the angle a little greater, but it is probably accidental.

(17) Probably no apparent motion.

(18) Only elongated.

(19) Separated at times. The distance may be getting smaller.

(20) This is almost exactly STRUVE's measure of 1825.

(21) Very little change in angle during the last fifteen years. The separation should be most carefully measured at present as it will very soon help to determine with accuracy the length of the major axis. According to LEWIS' orbit, the maximum distance should reach 1″.44.

(22) Comparison with the orbits of HUSSEY and SEE gives the following residuals: (O − C)

	HUSSEY		SEE	
	$\Delta\theta$	$\Delta\rho$	$\Delta\theta$	$\Delta\rho$
	°	″	°	″
09.83	+3.6	−0.23	+3.7	−0.28
11.11	+1.0	−0.19	+1.0	−0.24
15.57	+1.0	−0.12	+0.7	−0.17

Both orbits evidently have a computed separation too great at the present time.

(23) Not the least change in the last eighty years.

(24) In 1912 it was well separated by the 14-inch, but in 1914 the pair appeared too close for the 28-inch and only a slight elongation was noticeable.

(25) This is exactly STRUVE's measures of 1831.

(26) No apparent motion.

(27) I am inclined to doubt any variability in this pair.

(28) The companion has probably reached its maximum distance.

(29) This binary has been almost without apparent change in angle for the last forty years.

(30) Separation possibly getting smaller.

(31) No apparent change.

(32) If this is correct, the angle is increasing.

(33) The retrograde motion is doubtful. There is no apparent change in the last thirty years at least.

(34) No apparent change. Several times I thought that the faint star had possibly a 15th magnitude companion at 2″, 200°.

(35) These observations make the separation small but this may not be real as the inequality of magnitudes renders the pair rather difficult.

(36) This is a mean of two nights.

(37) Possibly a small increase in distance.

(38) The retrograde motion has been about 140° in the last twenty years.

(39) Elongated.

(40) Separated.

(41) The companion has probably now passed periastron.

(42) There seems to be a slow retrograde motion.

(43) Very slow retrograde motion of about 20° in seventy years.

(44) A mean of three nights. Slow retrograde motion of 30° in eighty years.

(45) The retrograde motion is not supported by the recent measures.

(46) Comparison with the orbits of Lohse and See gives the following residuals: (O — C).

	Lohse		See	
	Δθ	Δρ	Δθ	Δρ
	°	″	°	″
11.10	+0.9	−0.48	−6.0	−0.12
13.25	+1.0	−0.69	−5.5	−0.30
14.77	+2.0	−0.45	−4.3	−0.10
15.07	+2.3	−0.39	−3.5	−0.03
16.11	+0.4	−0.05	−5.5	+0.31
17.23	+2.0	−0.22	−3.7	+0.14

The position angle observed is best represented by Lohse's orbit of 1908. See's elements date as far back as 1895.

(47) Retrograde motion of only 0°.2 a year.

(48) Probably no sensible change.

(49) At present the angular motion is very rapid. The pair should be closely followed.

(50) The ephemeris given by Hussey by assuming the companion in rectilinear motion still holds good. Comparison with these measures gives:

	O — C	
	°	″
1911.20	+0.1	−0.05
16.32	+1.5	−0.20
17.24	0.0	−0.13

(51) The motion of this pair is not yet clear.

(52) On these four nights I saw "something" about twice as difficult as the companion of *Sirius* but the measures must be received with caution.

(53) No apparent motion. The discovery of this pair was a good performance for a 12-inch *mirror*.

(54) Direct motion of only 0°.2 a year and no certain change in distance.

(55) Comparison with See's elements gives residuals as follows: (O — C)

	Δθ	Δρ
	°	″
11.23	−2.0	+0.03
12.13	−1.0	+0.02
13.28	−3.2	+0.04
15.23	−3.0	+0.12
16.32	−4.3	−0.16
17.26	−4.5	−0.13

(56) In 1912 the elongation was distinct with the 14-inch, but the following years it was very uncertain with the 28-inch.

A rough comparison with Aitken's orbit gives: (O — C)

	Δθ	Δρ
	°	″
12.14	−12	−0.01
15.31	+24	+0.01

These observations are possibly of not much value, the pair being too close of late years.

(57) Comparison with the elements by Lohse and See gives the following residuals: (O — C)

	Lohse		See	
	Δθ	Δρ	Δθ	Δρ
	°	″	°	″
13.24	+23.0	+0.16	+2.8	+0.04
15.31	+10.0	+0.01	−0.5	−0.08
16.32	+10.2	−0.02	+1.3	−0.08
17.27	+ 2.5	−0.08	−4.9	−0.11

Lohse's orbit, published thirteen years after that of See, is not an improvement in this quadrant.

(58) A mean of two nights.

(59) Comparison with See's orbit gives: (O — C)

	Δθ	Δρ
	°	″
11.56	−1.9	0.00
13.24	−2.2	+0.09
15.31	−2.0	−0.19
17.26	+1.4	−0.21

(60) A mean of two nights.

(61) The period will evidently be very long.

(62) Separated.

(63) Elongated.

(64) See's orbit gives the following residuals: (O — C)

	Δθ	Δρ
	°	″
11.33	−2.1	+0.25
15.43	+0.3	+0.11
17.28	+1.7	+0.32

The pair is just observed at the maximum separation.

(65) No apparent change in the last twenty years. I do not observe any variability in the magnitudes.

(66) A mean of three nights.

(67) On these four nights the pair could not be separated by the large refractor.

Royal Observatory, Greenwich, 1917, April 29.

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Editor, Benjamin Boss, Albany, N. Y.; Associate Editors: E. E. Barnard, Ernest W. Brown, F. R. Moulton and R. S. Woodward.
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EXTRACTS FROM A PAPER ON ATMOSPHERIC REFRACTION,

By W. T. NEILL.

[Read before the Astronomical Branch, Otago Institute, N. Z., 26th Oct., 1915.]

The following investigation of the amount of the refraction is based on principles which depend on a rigorous solution of the equations deduced from the known laws of the refraction of light and the geometry of the problem; the computation of the refraction is consequently reduced to the solution of problems involving the elementary principles of geometry and optics.

The value of the results thus derived must be decided by their agreement with those obtained by observation at the place for which they are computed.

It will conduce to clearness if the fundamental equations of the law of refraction are derived directly from first principles.

Referring to Fig. 1, suppose EDB to represent the horizontal surface of a stratum of air of uniform density.

Let A denote the position of the eye of an observer and ACB the path of the ray of light from a star or luminous object at B.

Put v_0 the velocity of light in vacuo.

Put v the velocity of light within the air.

Put $AD = a$. $DB = b$. Angle $ACD = \alpha$.

If T denote the time of passage from B to A by the path BC, CA, then

$$T = \frac{AC}{v} + \frac{BC}{v_0}$$

$$= \frac{a \operatorname{cosec} \alpha}{v} + \frac{b - a \cot \alpha}{v_0}$$

By the law of FERMAT or the principle of least time we have

$$\frac{dT}{d\alpha} = 0 .$$

Thus $$\cos \alpha = \frac{v}{v_0} \tag{1}$$

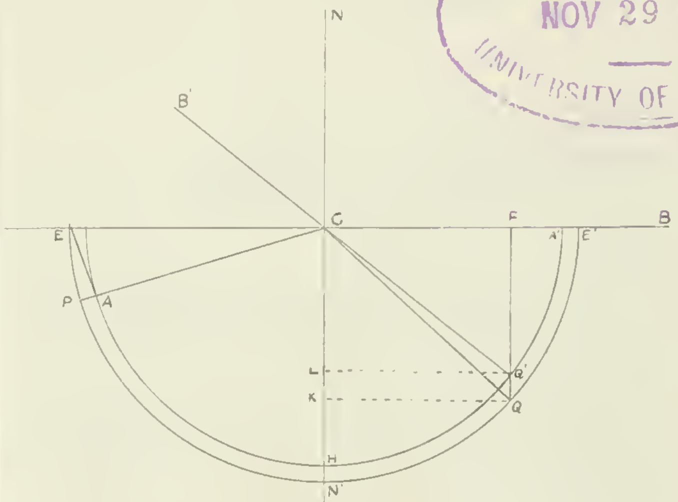

Fig 1

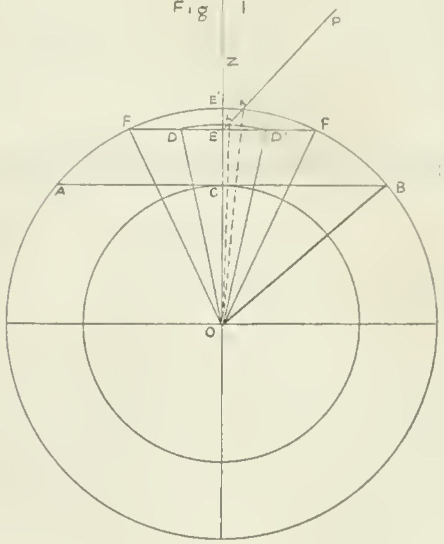

Fig. 2.

The reciprocal of $\cos\alpha$, $\frac{v_0}{v}$ is usually termed the refractive index of air and is denoted by μ.

At 50° F. and 30 in. Bar. its value is 1.0002835.
(Everett C.G.S. Units page 110.)

Let this value of α be represented by α_0.

$$\text{Thus} \qquad \sec\alpha_0 = \mu = 1.0002835.$$

$$\text{(2)} \qquad \text{and} \qquad \alpha_0 = 1^\circ\, 21'\, 51''.$$

Again $v = v_0 \cos\alpha_0$, and since velocities can be resolved by the parallelogram of velocities, there is another component $v_0 \sin\alpha_0$; which will be shown later to represent the vertical separation of the true and apparent positions.

Let CA represent v in direction and magnitude.

Draw AE perpendicular to AC, and NCN' the normal at C.

Then CE and AE represent v_0 and $v_0 \sin\alpha_0$ respectively.

Denote the angle of incidence by I.

Denote the angle of refraction by R.

Denote the amount of refraction by θ.

From C as center with radii CE, CA describe the semi-circles $EN'E'$, AHA'.

Now the angle α_0 is the amount of refraction when the angle of incidence is 90°, and therefore, $90^\circ - \alpha_0$ is the critical angle where refraction ceases and total reflection begins.

In the case under consideration the angle of incidence NCB is a right angle and ACN' is the angle of refraction.

From the figure it is clear that

$$\angle NCB = \angle ACN' + \angle ACE.$$

$$\text{or} \qquad I = R + \alpha_0.$$

The triangle ACE gives the relation

$$\frac{EC}{AC} = \frac{\sin I}{\sin R}.$$

$$\text{(3)} \qquad \frac{v_0}{v} = \frac{\sin(R + \alpha_0)}{\sin R} = \mu\,.$$

Let $B'C$ represent the path of a ray of light when the incident angle is less than a right angle. Produce $B'C$ to intersect the circle AHQ' at Q'.

Draw a vertical line through Q', meeting the surface at F and intersecting the circle ENE' at Q. Join CQ.

From the triangle CQQ' we have

$$\frac{CQ}{CQ'} = \frac{\sin CQ'F}{\sin CQF} = \frac{\sin I}{\sin R}$$

$$\text{or} \qquad \frac{v_0}{v} = \frac{\sin I}{\sin R} = \frac{\sin(R+\theta)}{\sin R} = \mu\,. \qquad (5)$$

The expression represented by (5) is known as Snell's law of sines.

$$\text{From (5)} \qquad v_0 \sin R = v \sin I$$

$$\text{or} \qquad KQ = LQ'.$$

Thus the apparent position Q' is vertically above the true position Q, to an eye at C.

$$\text{Now } QQ' = FQ - FQ' = CQ\,(\cos R - \cos\alpha_0 \cos I)$$
$$= CQ\,(\cos R - \sqrt{\cos^2\alpha_0 - \sin^2 R}\,)$$

or apparent vertical displacement

$$= CQ \sin\alpha_0. \quad \text{When } R = 90^\circ - \alpha_0.$$

apparent vertical displacement

$$= CQ\,(1 - \cos\alpha_0). \quad \text{When } R = 0.$$

Developing equation (5) to terms of the first order in θ we find

$$\theta = (\mu - 1)\tan R\,. \qquad (6)$$

$$\text{or} \qquad \theta = \frac{\mu - 1}{\mu}\tan I\,. \qquad (6a)$$

At the apparent horizon $R = 90^\circ - \alpha_0$, and (6) gives

$$\theta = \frac{1 - \cos\alpha_0}{\cos\alpha_0}\cot\alpha_0 = \tan\frac{\alpha_0}{2}\,.$$

or $\theta = \frac{\alpha_0}{2}$ nearly, since θ and α_0 are small.

Thus at the apparent horizon the approximation represented by equation (6) gives for the refraction about one half its correct value.

To determine the amount of refraction by a rigorous solution of equation (5) we have

$$\sin(R + \theta) = \mu \sin R$$
$$\cos\theta + \sin\theta\cot R = \mu$$
$$1 + \tan\theta\cot R = \mu\,(1 + \tan^2\theta)^{\frac{1}{2}}$$

Squaring, and solving for $\tan\theta$ gives: —

$$\tan\theta = \frac{\cot R}{\mu^2 - \cot^2 R} \pm \left[\frac{\cot^2 R}{(\mu^2 - \cot^2 R)^2} - \frac{\mu^2 - 1}{\mu^2 - \cot^2 R}\right]^{\frac{1}{2}} \qquad (7)$$

Expanding the quantity under the radical and taking the negative as the admissible sign, the following infinite series results: —

$$\tan\theta = \frac{\mu^2-1}{2}\tan R + \frac{(\mu^2-1)^2}{8}\tan^3 R\,(\mu^2-\cot^2 R)$$

$$(8) \qquad + \frac{(\mu^2-1)^3}{16}\tan^5 R\,(\mu^2-\cot^2 R)^2 + $$

At the limiting value of R, viz., 90° − a_0, we have

$$\mu^2 - \cot^2 R = 1$$

and
$$\tan\theta = (\mu^2-1)\cot a_0(\tfrac{1}{2}+\tfrac{1}{8}+\tfrac{1}{16}+\text{etc.})$$
$$= \tan a_0$$
$$\therefore \theta = a_0.$$

This series therefore gives a correct value for the refraction for all values of the incident angle from 0° to 90°.

When
$$\mu^2 - \cot^2 R = 0$$
$$\cot R = \pm\mu.$$

and

$$(9) \qquad \tan\theta = \frac{\mu^2-1}{2\mu}.$$

This value of the refraction corresponds to a mean value of the angles of incidence and refraction equal to 45°.

Thus when

$$\left\{\begin{array}{l} I - R = \theta \\ I + R = 90°. \end{array}\right. \quad I = 45° + \frac{\theta}{2}, \text{ and } R = 45° - \frac{\theta}{2}.$$

The expansion in terms of tan I is: —

$$\tan\theta = \tan I\left\{\frac{\sin^2 a_0}{2} - \frac{\sin^4 a_0}{8}(\cos^2 a_0\tan^2 I - 1)\right.$$

$$(10) \qquad \left. + \frac{\sin^6 a_0}{16}(\cos^2 a_0\tan^2 I - 1)^2 + \dots\right\}$$

When $\cos^2 a_0 \tan^2 I - 1 = 0$

$$\tan I = \sec a_0$$

and
$$\tan\theta = \frac{\sin a_0\tan a_0}{2} = \frac{\mu^2-1}{2\mu} \text{ as above.}$$

Effect of Sphericity on the Amount of Refraction

The refraction at a point on a spherical surface is the same as that at a surface which is tangent to the sphere at the given point and it is independent of the radius of the sphere.

When however the refracted ray passes through a given point within the sphere the radius of the sphere and the position of the point are required for the solution of the problem.

Let Fig. 2 represent a vertical section through the center of a transparent sphere of radius r.

Draw AB and OE to denote sections of the horizontal and vertical planes through C.

To an eye at O the point E' on the actual surface appears at E on the apparent surface of radius r/μ. Draw the tangent FEF' to the apparent surface at E meeting the actual surface at F and F'. Join OF, OF',

Now
$$\cos EOF = \frac{r}{\mu r} = \frac{1}{\mu} = \cos a_0$$

Therefore
$$EOF = a_0,$$

the complement of the critical angle of a plane surface tangent to the sphere at F. We will refer to the point E as the "critical point," above it a horizontal ray within the sphere is totally reflected since the angle

$$EFO = \frac{\pi}{2} - a_0.$$

From the center O and radius OC describe a circle to represent a section of the *Earth*, supposed spherical, and consider the annular space between the two circles to be a section of the atmosphere.

Now since the amount of refraction of a gas of varying density depends only on the density of the lowest stratum it will not be altered if we conceive the density to be uniform and the height of the transparent shell equal to the pressure height. This supposition is equivalent to CASSINI's hypothesis, which is known to be defective at large zenith distances.

The apparent failure of CASSINI's hypothesis is due to an erroneous supposition that the angle OBC is the angle of refraction of the horizontal ray which passes through the point C.

In order to obtain a relation between the apparent zenith distance and the angle of refraction that will give an accurate value of the amount of refraction of a ray that passes through a given point within the sphere the resolved velocity of light in the horizontal direction must be known.

The particular case in which the given point within the sphere is the "critical point" is first considered. In this case the velocity of the horizontal ray through E is v.

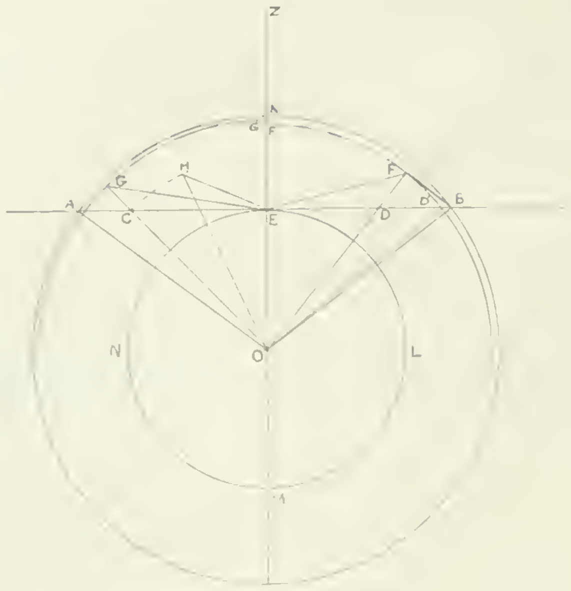

Fig 3

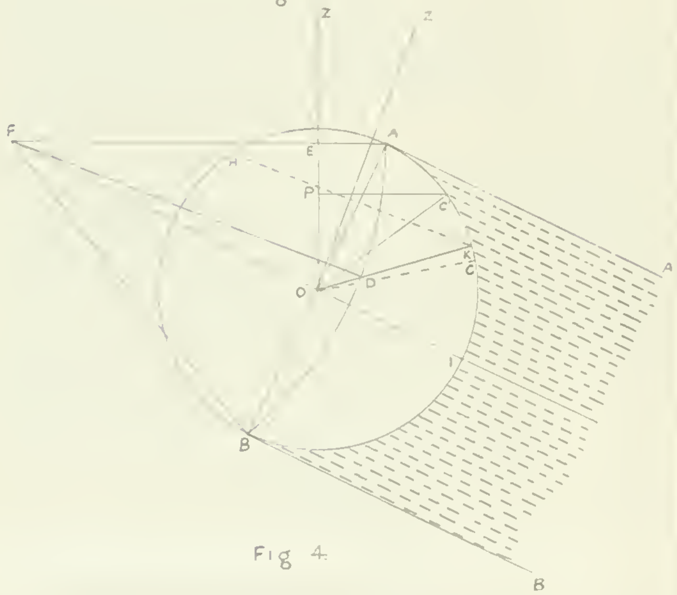

Fig 4

On the arc FEF' the tangent at any point K makes an angle with the horizon equal to the amount of refraction corresponding to an angle of incidence which is equal to the apparent zenith distance of the refracted ray. The refraction at the point K on the spherical surface is therefore the same as the refraction at the point E on the plane surface FEF'.

For instance the refraction at E due to the plane surface FF' for the ray EP is the angle EOK, and we have from the triangle EOK

$$\sin Z : \sin EKO = OK : OE = OF : OE$$

or

$$\sin Z = \mu \sin EKO. \qquad (11)$$

The refraction at the point K on the spherical surface is given by the equation

$$\sin EKO = \sin Z \sin EF'O$$

or

$$\sin Z = \mu \sin EKO. \qquad (12)$$

These results probably explain why the refractions are not much affected by sphericity to zenith distances of 75°.

The case in which the given point lies between the "critical point" and the center of the sphere corresponds to a point on the surface of the *Earth* for which the refraction due to the homogeneous atmosphere is required for apparent zenith distances from 0° to 90°. Let Fig. 4, represent a vertical section through the center of a transparent sphere.

Suppose a light wave represented in section by AA', BB' to meet the spherical surface AIB, and that AB is a diameter of the sphere making an angle α_0 with OZ, which represents the vertical line through the center O.

Since AA' and BB' are tangent to the sphere at A and B respectively, the rays of light at these points are refracted in the directions AF, BF, the angles ABF, BAF are each equal to $90° - \alpha_0$, and AF is a horizontal line passing through the critical point E.

Let P be a point for which the refractions are required. Put $OP = r$, and the radius of the sphere $r + h$. Join FO by a straight line and produce it to intersect the sphere at I.

The point I is the zero or initial from which angles of incidence and refraction are measured. Between I and A the parallel rays of light make angles of incidence from 0° to $\frac{\pi}{2}$ on the spherical surface.

Again Z is the point that zenith distances are measured from. Draw a horizontal line from P to meet the spherical surface at C'. Join OC', and let the angle $PC'O$ be denoted by R.

The angle R is defined by the equation

$$\sin R = \frac{r}{r + h}. \qquad (13)$$

From O draw OC making the angle IOC equal to R, and OK making angle IOK equal to the angle of incidence, determined by the equation

$$\sin IOK = \mu \sin IOC = \mu \sin R.$$

From F as center with radius FA describe the arc ADB intersecting OK at D. Join DF.

From the triangle DFO we have

$$\sin IOK : \sin FDO = FD : FO = AF : FO$$

$$\text{or } \sin IOK = \mu \sin ODF \tag{14}$$

The angle FDO is therefore equal to the angle of refraction and DFO to the amount of refraction corresponding to the angle of incidence IOK. Further DF is parallel to the path of the refracted ray, shown by the broken line KH.

From O draw OZ' perpendicular to DF and denote the angle DFO by β_0.

Then the angle $ZOZ' = \angle AFD = \angle AFO - \angle DFO$

$$= \alpha_0 - \beta_0 \tag{15}$$

is the angle that the refracted ray makes with the horizon.

The horizontal component of the velocity of the refracted ray is therefore $v \cos (\alpha_0 - \beta_0)$.

Denote the angle of refraction of the horizontal ray which passes through P by R_0, it is obvious that

$$R_0 = R + \alpha_0 - \beta_0 \tag{16}$$

To find the amount of refraction at the point P for an apparent zenith distance Z we put

α_z and β_z the values of α and β at an apparent zenith distance Z

From O Fig. 2, draw OD, OD' making the angles EOD, EOD' each equal to β_0, and describe the arc DLD' with radius OD.

$$\text{Let } \sec \beta_0 = m. \tag{17}$$

When $Z = \frac{\pi}{2}$ we have

$$\angle EOF = \alpha_0, \quad \angle EOD = \beta_0.$$

If $PKLE$ represents the ray at a zenith distance Z we have

$$\angle EOK = \alpha_z, \quad EOL = \beta_z$$

The triangle EOK gives

$$\sin Z = \mu \sin EKO = \mu \sin (Z - \alpha_z). \tag{18}$$

From the triangle EOL we obtain

$$\sin Z = m \sin (Z - \beta_z) \tag{19}$$

A result similar to the law of refraction but open to criticism. Then if R_z is the angle of refraction at an apparent zenith distance Z, we put

$$R_H = R + \alpha_z - \beta_z \tag{20}$$

and $$\sin R_z = \sin R_H \sin Z. \tag{21}$$

These angles are shown in Fig. 3, which is a geometrical representation of the hypothesis by means of which the refraction is computed. Let O be the center of the *Earth*, supposed spherical, $ELMN$ a vertical section through the center, AKB a section of the portion of the homogeneous atmosphere above the horizon plane AB, and OZ the vertical line through a point E on the *Earth's* surface.

Denote the equal angles EAO, EBO by R.

Denote the angle EDO by R_0.

Denote the angle ECO by R_H.

Denote the angle EHO by R_z.

Again referring to Fig. 4, we have the resolved velocities parallel to the horizon as follows: —

Resolved component in vacuo $= r_0 \cos \alpha_0 = r$.

Resolved component within the medium $= r \cos (\alpha_0 - \beta_0)$ corresponding to the point P; thus with the adopted zenith we have, that in the time taken by the horizontal component of the ray to travel the distance $(r + h)$ in vacuo, it will travel the distance $(r + h) \cos (\alpha_0 - \beta_0)$ within the medium in the same direction.

Now from the center O, Fig. 3 with radius $(r + h) \cos (\alpha_0 - \beta_0)$ describe the arc $F'FD'$. From E draw EF making the angle $DEF = \alpha_0 - \beta_0$. Join OF, OB, OD', FB.

From the geometry of the figure we have

$$\sin EBO = \sin ED'O \cos (\alpha_0 - \beta_0) = \sin EFO.$$

$$\therefore \angle EBO = \angle EFO = \mathrm{R}.$$

it follows that EDF and ODB are similar triangles. Thus the angle $FOB = \alpha_0 - \beta_0$, and, OFB being a right angle, OF and FB represent the two component velocities of the refracted ray.

Again $$\angle EDO = \angle EBO + \angle FOB$$

or $$R_0 = R + \alpha_0 - \beta_0.$$

To obtain the angle of refraction for a zenith distance Z. We find α_z and β_z from (18) and (19), developed in series for accurate results at large zenith distances.

From E draw EG making the angle AEG equal to $\alpha_z - \beta_z$. From O with radius $(r + h) \cos (\alpha_0 - \beta_0)$ describe the arc GG'. Join OG, intersecting AE at the point C. Again from O with radius OC describe the arc CH and let ZEH be the apparent zenith distance of the ray EH. Join OH.

Then the angle $ECO = R + \alpha_z - \beta_z$.

or $$R_H = R + \alpha_z - \beta_z.$$

and $$\sin EHO = \sin R_H \sin Z.$$

or $$\sin R_z = \sin (E + \alpha_z - \beta_z) \sin Z.$$

It is therefore evident that this method of computing the refractions is similar to that proposed by CASSINI but instead of the change of direction of the path of a ray of light taking place on a definite outer surface of the homogeneous atmosphere it is supposed to take place on imaginary concentric surfaces, the radii of which increase with the altitude.

At the zenith the imaginary surface coincides with the surface of the homogeneous atmosphere.

Refractions based on the assumption of a spherical atmosphere will require a correction on account of the spheroidal form of the *Earth*. The equipotential surface of the homogeneous atmosphere is probably well represented by a confocal ellipsoid of the meridian ellipse. The refraction on such a surface would vary with the azimuth, and except at the poles or the equator the refraction for a meridional zenith distance south would not agree with the refraction for the same meridional zenith distance north.

On the assumption of a spherical *Earth* the appended table of mean refractions was computed by the writer for experimental purposes.

The value of the index of refraction at 50° F. and 30 in. Bar. used in computing the table is 1.00028263 (NEWCOMB'S *Comp. of Sp. Ast.* p. 194).

At 45° latitude the value of the radius of curvature by HELMERT'S Spheroid is 6367554m. The pressure height at latitude 45° for 50° F. and 30 in. Bar. allowing for variable gravity is 8305m.

TABLE OF ATMOSPHERIC REFRACTION.

MEAN REFRACTION AT 50° FAHR., 30 IN. BAR., 45° LATITUDE.

App. Z. D.	Mean Refraction	Correction at Temperature		Correction at Barometric Pressure		App. Z. D.
		40° F.	60° F.	29 in.	31 in.	
°	″	″	″	″	″	°
0	0.00	+ 0.00	− 0.00	− 0.00	+ 0.00	0
1	1.02	0.02	0.02	0.03	0.03	1
2	2.03	0.04	0.04	0.07	0.07	2
3	3.05	0.06	0.06	0.10	0.10	3
4	4.07	0.08	0.08	0.14	0.14	4
5	5.09	+ 0.10	− 0.10	− 0.17	+ 0.17	5
6	6.12	0.12	0.12	0.21	0.21	6
7	7.15	0.14	0.14	0.24	0.24	7
8	8.18	0.16	0.16	0.28	0.28	8
9	9.22	0.18	0.18	0.31	0.31	9
10	10.27	+ 0.21	− 0.21	− 0.34	+ 0.34	10
11	11.32	0.23	0.23	0.38	0.38	11
12	12.38	0.25	0.25	0.41	0.41	12
13	13.44	0.27	0.27	0.44	0.44	13
14	14.52	0.29	0.29	0.48	0.48	14
15	15.60	+ 0.31	− 0.31	− 0.52	+ 0.52	15
16	16.70	0.33	0.33	0.55	0.55	16
17	17.80	0.35	0.35	0.59	0.59	17
18	18.92	0.37	0.37	0.63	0.63	18
19	20.04	0.39	0.39	0.67	0.67	19

App. Z. D.	Mean Refraction	Correction at Temperature 40° F.	Correction at Temperature 60° F.	Correction at Barometric Pressure 29 in.	Correction at Barometric Pressure 31 in.	App. Z. D.
°	"	"	"	"	"	°
20	21.19	+ 0.42	− 0.42	− 0.71	+ 0.71	20
21	22.35	0.44	0.44	0.75	0.75	21
22	23.52	0.46	0.46	0.79	0.79	22
23	24.71	0.48	0.48	0.83	0.83	23
24	25.92	0.51	0.51	0.87	0.87	24
25	27.15	+ 0.54	− 0.54	− 0.91	+ 0.91	25
26	28.39	0.56	0.56	0.95	0.95	26
27	29.66	0.58	0.58	0.99	0.99	27
28	30.95	0.61	0.61	1.03	1.03	28
29	32.26	0.64	0.64	1.08	1.08	29
30	33.60	+ 0.67	− 0.67	− 1.12	+ 1.12	30
31	34.97	0.69	0.69	1.17	1.17	31
32	36.37	0.72	0.72	1.21	1.21	32
33	37.79	0.74	0.74	1.26	1.26	33
34	39.26	0.77	0.77	1.31	1.31	34
35	40.75	+ 0.80	− 0.80	− 1.36	+ 1.36	35
36	42.28	0.83	0.83	1.41	1.41	36
37	43.84	0.86	0.86	1.46	1.46	37
38	45.46	0.89	0.89	1.52	1.52	38
39	47.12	0.93	0.93	1.57	1.57	39
40	48.82	+ 0.97	− 0.97	− 1.63	+ 1.63	40
41	50.57	1.00	1.00	1.69	1.69	41
42	52.37	1.03	1.03	1.75	1.75	42
43	54.24	1.08	1.08	1.81	1.81	43
44	56.17	1.11	1.11	1.88	1.88	44
45	58.16	1.15	1.15	1.94	1.94	45
45	0 58.2	+ 1.2	− 1.2	− 1.9	+ 1.9	45
46	1 0.2	1.2	1.2	2.0	2.0	46
47	1 2.4	1.3	1.3	2.1	2.1	47
48	1 4.6	1.3	1.3	2.1	2.1	48
49	1 6.9	1.3	1.3	2.2	2.2	49
50	1 9.3	+ 1.4	− 1.4	− 2.3	+ 2.3	50
51	1 11.8	1.4	1.4	2.4	2.4	51
52	1 14.4	1.5	1.5	2.5	2.5	52
53	1 17.1	1.5	1.5	2.6	2.6	53
54	1 20.0	1.6	1.6	2.7	2.7	54
55	1 23.0	+ 1.6	− 1.6	− 2.8	+ 2.8	55
56	1 26.1	1.7	1.7	2.9	2.9	56
57	1 29.4	1.7	1.7	3.0	3.0	57
58	1 32.9	1.8	1.8	3.2	3.2	58
59	1 36.6	+ 1.9	− 1.9	− 3.3	+ 3.3	59

App. Z. D.	Mean Refraction	Correction at Temperature 10° F.	Correction at Temperature 60° F.	Correction at Barometric Pressure 29 in.	Correction at Barometric Pressure 31 in.	App. Z. D.
°	″	″	″	″	″	°
60	1 10.5	+ 2.0	− 2.0	− 3.4	+ 3.4	60
61	1 14.6	2.1	2.1	3.6	3.6	61
62	1 19.1	2.2	2.2	3.7	3.7	62
63	1 53.8	2.2	2.2	3.8	3.8	63
64	1 58.8	2.3	2.3	3.9	3.9	64
65	2 4.2	+ 2.4	− 2.4	− 4.1	+ 4.1	65
66	2 10.0	2.5	2.5	4.3	4.3	66
67	2 16.3	2.6	2.6	4.5	4.5	67
68	2 23.1	2.8	2.8	4.7	4.7	68
69	2 30.5	2.9	2.9	4.9	4.9	69
70	2 38.6	+ 3.1	− 3.1	− 5.2	+ 5.2	70
71	2 47.5	3.3	3.3	5.5	5.5	71
72	2 57.3	3.5	3.5	5.8	5.8	72
73	3 8.2	3.7	3.7	6.2	6.2	73
74	3 20.3	4.0	4.0	6.6	6.6	74
75	3 34.0	+ 4.3	− 4.3	− 7.1	+ 7.1	75
76	3 49.5	4.6	4.6	7.6	7.6	76
77	4 7.2	5.0	5.0	8.1	8.1	77
78	4 27.6	5.5	5.5	8.8	8.8	78
79	4 51.4	6.0	6.0	9.6	9.6	79
80	5 19.4	+ 6.6	− 6.6	− 10.4	+ 10.4	80
81	5 52.9	7.4	7.4	11.3	11.3	81
82	6 33.7	8.4	8.4	12.5	12.5	82
83	7 24.4	9.6	9.6	14.0	14.0	83
84	8 28.6	11.4	11.3	15.7	15.7	84
85	9 51.9	+ 13.6	− 13.6	− 17.7	+ 17.8	85
86	11 43.8	17.1	17.0	20.4	20.5	86
87	14 18.9	23.1	22.4	23.6	23.9	87
88	18 4.6	33.5	31.6	27.5	27.9	88
89	24 13.2	57.0	53.6	32.8	34.5	89
90	34 32.4	+ 105.5	− 96.4	− 34.9	+ 38.6	90

NOTE.

G. W. Hill, *Coll. Math. Works* IV.

Errata. Table of $\left(\frac{r}{a}\right)$ on p. 400:

$e^6 C\,0f$ For 22834 read 22824

$e^4 C\,2f$ " 5 " -5

also

p. 402, 3d line of formulas. For $\frac{31}{4}$ read $\frac{81}{4}$

15th " " " $\frac{15}{2}+\frac{5}{2}$ " $\frac{15}{2}-\frac{5}{2}$

p. 403, 3d " " " $\frac{35}{16}$ " $\frac{70}{16}$

R. T. A. I.

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ON THE ORBIT OF (132) *AETHRA*,

By A. ESTELLE GLANCY.

In 1913, interest in this lost planet was revived through the announcement (*M. N.*, 75, 310) by CROMMELIN of a suspected identity between *Aethra* and an asteroid between the eighth and ninth magnitude photographed at the Lowell Observatory with the forty-inch reflector on June 10, 1913. This announcement led to search ephemerides for July 19 to Sept. 13, 1914 by LUTHER (*A. N.*, 4751, 4754); for Oct. 1, 1915 to Mar. 1, 1916 by ALTER (*L. O. B.*, No. 275), and Dec. 1, to Aug. 1, 1917 by ALTER (*L. O. B.*, No. 285) — all based on this identity.

The identity seemed so probable to the writer that a photographic search was begun on Dec. 1, 1916, using a photographic telescope of 64 cm. focal length and an aperture stopped down to 10 cm. Owing to various interruptions, most of the plates were taken during the lunations of February and March, 1917. They cover a wide area around 16^h R. A. and $-44°$ Dec., Duplicate fields, one or more days apart, were compared in the stereo-comparator. By chance *Eros* was found on several of these plates. It was then about 10.2 magnitude. The image was strong and very striking in the stereo-comparator. There were no other moving objects found on these plates. It is probably safe to say that no asteroid brighter than eleventh magnitude was in this region.

About this time I had occasion to refer to the original Lowell observation. It was noticed that the observed position falls within the Cordoba astrographic zone. Search among the Cordoba plates revealed unexpectedly a plate taken on June 9, 1913 with center

$$\text{R. A.} = 15^h\,27^m\,0^s \qquad \text{Dec.} = -28°\,0'$$

The Lowell observation is (*Lowell Obs. Bull.*, No. 61):

$$\text{Gr. M. T.} \quad 1913, \text{ June } 10.835$$

$$\text{R. A.} = 15^h\,27^m\,13^s \quad \text{Dec.} = -28°\,25'.6$$

According to ALTER's elements (*L. O. B.*, No. 285), the daily motion of *Aethra* would be

$$-32^s.3 \qquad\qquad +17'.1$$

The interval between the two photographs is 1.2 days. Hence on June 9 the Lowell object, if identical with *Aethra*, should have been in the position

$$\text{R. A.} = 15^h\,27^m\,52^s \qquad \text{Dec.} = -28°\,46'$$

a position well situated on the Cordoba plate. This plate was set in the stereo-comparator and its entire area was examined with the aid of four additional plates covering it in quarter sections. No moving object was found.

There seems only one conclusion to draw: that *Aethra* is not identical with the Lowell object. In fact, the absence of any asteroid on the Cordoba plate suggests that the Lowell object may be one of those spurious images which are often found.

Here is a good opportunity to emphasize the caution necessary in the identification of asteroids. The images of *Eros* mentioned above were at first mistaken for the object of search. Curiously enough a good representation was obtained using the general elements, Table X, *L. O. B.*, No. 275, assuming $\mu = 882''.525$. A micrometer observation on March 29 left the residuals

$$\Delta\alpha \cos\delta = -10^s \qquad \Delta\delta = +39'$$

This value of μ is only $0''.9$ less than the value adopted for the representation of the Lowell object; the representation is closer than that for the Lowell object. It would have seemed conclusive had the geocentric motion not been known. An observation on the following day left the unexpected residuals $+50^s$ and $-42'$. It so happened that the theoretical and the observed motion were just turning from the direct to retrograde direction; the ephemeris motion was north, the observed motion south.

Considering that there are over eight hundred planets there must often be two in neighboring directions, and it is a very easy matter to alter the elements of one to fit the neighboring position. A rigid identification would require a satisfactory representation in position, velocity and acceleration; in general, it should be sufficient to satisfy the first two conditions, preferably by two observations, or, in the case of a single photographic image, the direction of the trail should be published with an estimate of the magnitude of the daily motion, and in the latter case the investigator should be very cautious in drawing conclusions, no matter how real the image may appear.

In *L. O. Publ.*, Vol. 7, p. 462, the statement is made that the planet *Aethra* was lost owing to the neglect of the perturbations by *Mars* during the period of observation. Some recent investigations by me have led to a different conclusion.

Through an error in making a model of the orbit, I thought there was a close approach to *Mars* during the interval 1873, June 13 to July 5, although I did not recall at the time the statement referred to above. From a study of *L. O. B.*, Nos. 275, 285, it seemed to me that an orbit based on LEUSCHNER's method for the *Direct Solution of Orbits of Disturbed Bodies*, (*L. O. Publ.* 7, Part 9)*, might give elements so different that they would prove an identity between *Aethra* and some other known asteroid.

So this method as developed for satellite orbits was adapted to the case of a minor planet disturbed by *Mars*.

Then calculations were begun, based on the three normal places given in *L. O. B.*, No. 275†. It was seen at once that the model of the orbit was in error, and when correctly constructed the planet and *Mars* were much further apart, and the disturbing influence was so much diminished that it could be neglected. At the time of the middle observation the relative positions were

June 25.5, 1873	geocentric distance	1.5
	heliocentric distance	2.5
	distance from *Mars*	1.1

Nor was *Jupiter* near.

What later perturbations *Aethra* may have suffered we cannot say, for the elements are too uncertain to establish its position in following years.

Some calculations have been made to form an idea of the probability that *Aethra* was subject to the disturbing influence of another asteroid.

Taking the orbit of *Aethra* as the fundamental plane, the distance of *Aethra* from the *Sun* and the corresponding distances of the first 131 planets have been computed for each node. The elements of *Aethra* are *AI.* (*L. O. B.*, No. 275); those of the other planets were taken from *B. J.* 1918. No account has been taken of the difference in equinox since the calculations are only approximate. In the cases of thirteen planets the radii vectores differ less than 0.1 astr. units at the ascending node; there are twenty-two planets within the same limit at the descending node. And, more generally speaking, accepting the elements given by BARTON*, (*A. J.*, 702), the average asteroid passes above the plane of *Aethra* at a distance 1.0 units further from the *Sun* than *Aethra*, and passes below the orbit 0.3 closer.

With these geometrical relations a close approach depends only upon the relative positions in the orbits. If a planet's mean motion were exactly equal to that of *Aethra* a passage at the node would never occur except in the one possible case that it always occurs. On the other hand, those planets which can make a close approach must have nearly the same semi-major axis, except as relative eccentricity widens the range. It so happens that a close approach is more likely at the descending node, owing to the smaller eccentricity and larger semi-major axis of the average planet. Most of the thirty-five planets mentioned above have mean motions differing 100″ or less from that of *Aethra*. Suppose the mean motions differ 50″ and the planets are 180° apart when one passes a node. Neglecting the eccentricity, only thirty years would elapse before there would occur a passage at the node.

The planets discovered earlier than *Aethra* were used in the calculations as representative of all and relatively most important, since, in general, the earlier planets have the greater size. Among the thirty-five planets there are twenty-four having a smaller value of g than *Aethra*. (g = magnitude at opposition when reduced to $\rho = r = 1$). Taking g as a measure of size, it is probable that these planets are larger than *Aethra*. In this connection an estimate of the probable diameter of *Aethra* has been made.

Assuming the geocentric albedo, p, to be equal to the mean of the values so far known, using the magnitude at mean opposition given in *B. J.*, and the semi-major axis by ALTER,

$$p = 0.24 \quad m_0 = 10.9 \quad \log a = 0.410 \quad \text{diameter} = 70 \text{ km.}$$

---

*The following errors in the text were noted:
p. 471, line 15, for $a''(\tan \delta)''$, read $a'(\tan \delta)''$
p. 476, line 23, for that "m would appear in the place of γ," read "a multiplication by m throughout."

†For the date of the first normal place, June 18.5 read June 19.5.

*The value of π seems to be in error by about 180°; it was not used.

The relation between albedo and diameter is found in *Ap. J.* 43, 173. This value has a large probable error, for the albedos of individual planets are known to vary widely, (0.05 to 0.48). Using $p = 0.40$ the diameter would be 110 km.

Of the density of the asteroids little can be said, except that it is probably comparable with that of the denser planets or the meteors. If we assume the density of *Mars*, (3.9), an asteroid of diameter 208 km. at a distance of 0.005 astr. units would have approximately the same influence as *Mars* itself at a distance 0.2.

It seems reasonable to conclude that *Aethra* is larger than the average asteroid, but smaller than many of those discovered earlier and that a sufficiently close approach to any of the above mentioned twenty-four, (they are 3, 7, 8, 9, 14, 19, 20, 23, 26, 27, 30, 32, 37, 57, 59, 61, 70, 78, 79, 88, 100, 103, 114, 119), would change the orbit considerably. There should be included in this list a few others discovered later, for which the calculations have not been made.

Take for example the asteroid (3) *Juno*, whose diameter and albedo have been measured. The diameter is 203 km. (Bell, *Ap. J.* 45, 11). On the basis of Alter's elements of *Aethra* and the elements of *Juno* found in *B. J.* 1875, *Juno* would have passed its descending node upon the plane of *Aethra* about Jan. 5, 1878, just following *Aethra*. By applying a small negative correction to the position of this node and a small negative correction to *Aethra's* mean motion a hypothetical collision could be made.

More approximate calculations show that a correction $\Delta\mu = -15''$ to $-20''$ to *Aethra* would give a close approach at the descending node of (8) *Flora* in 1880.7.

There is another possibility. Certain asteroids, notably *Eros*, have shown considerable variability in brightness. An extreme case is (77) *Frigga*. This planet was discovered in 1863, lost in 1865, re-discovered in 1879. In *A. N.* 97, 147, Peters has established that, in order to account for the failures to find it in 1865, 66, 70, 71, 73, the brightness must have diminished greatly, passing from the eleventh to fainter than thirteenth magnitude. In this connection it should be recalled that the brightness of *Aethra* depends solely on a statement by Luther in 1892 that *Aethra* was of the 11th magnitude in 1873.

Summarizing the preceding as well as some facts brought out by Luther and Alter:

The orbit of *Aethra* is very uncertain. It is based on an arc of only twenty-two days. Various attempts to improve the elements by slight corrections to the observations or by selection of the observations show how sensitive this orbit is to small errors of observation. The mean motions differ from 844″ to 980″. In fact, the circle and the parabola are just outside the range of solution. One of these orbits suggests the possibility that the mean motion was almost exactly three times that of *Jupiter*, in which case it may have been lost through perturbations.

During the period of observation neither *Jupiter* nor *Mars* was close to the planet.

Aethra is not identical with the 1913 Lowell object.

There is a possibility that *Aethra* has been perturbed by some other asteroid larger than itself.

Aethra is only one of numerous planets which have not been seen since the year of discovery. One lost planet, (77) *Frigga*, when found again, was proved to have so diminished in brightness as to have escaped searches two magnitudes fainter than predicted. It is noticeable that lost planets in general show high inclinations and eccentricities, thereby causing large differences in magnitude at various oppositions and apparent paths outside the usual field of search.

Of all the possibilities, the most probable seems to be that *Aethra* has only chanced to elude observers, partly because of its high inclination and eccentricity and possibly through a large unknown variability in brightness. As pointed out by Alter, the favorable oppositions occur when the planet is far south of the equator. There would be the greatest probability of success if a search were made at some southern observatory during the spring of one or more years, covering the apparent path on the assumption of a wide range in orbital position.

Extending the same suggestion further, asteroid searches outside the equator and ecliptic might result in some very interesting discoveries for this is where we should look for planets very close to the *Earth*. The one objection to this plan is perhaps the large area of sky which would have to be examined for the reward of a single unusual planet.

Observatorio Nacional, Cordoba,
June 22, 1917.

NOTE

Some time ago a letter was sent to the Lowell Observatory stating the reasons for questioning the genuineness of the asteroid image on the Lowell plate of June 10, 1913, and inquiring about the character of the trail, its direction and the approximate daily motion and possible confirmation on a duplicate field. The above paper has been withheld from publication awaiting a reply.

A letter has just been received from Astronomer C. O. Lampland, who has courteously detailed the evidence upon which the reality of the image rests. Summing up briefly: the plate is a fifteen-minute exposure with the forty-inch reflector, of inferior quality owing to haze and clouds; the elongated image has all the appearance of a bright asteroid; duplication of the field is lacking owing to a long period of unfavorable weather; the direction of elongation and the daily motion are very uncertain, but, as nearly as can be determined, the motion is about parallel to the equator and from 10′ to 12′ per day.

Concerning the possible identification with *Aethra*, the daily motion of *Aethra*, according to the elements by ALTER, would produce a trail inclined about sixty degrees to the observed motion.

Concerning the reality of the image, the asteroid, assuming retrograde motion, ought to be on the Cordoba Astrographic plate of June 9, 1913 in the neighborhood of

$$15^{h}\,28^{m}.1 \qquad -28^{\circ}\,26'$$

Assuming direct motion, it should be in the neighborhood of

$$15^{h}\,26^{m}.3 \qquad -28^{\circ}\,26'$$

August 21, 1917.

NOTE BY DR. LEUSCHNER.

Dr. A. O. LEUSCHNER has added the following footnote to Dr. GLANCY's paper. Dr. GLANCY has asked me to verify certain errata which she has picked up in addition to those already published. I have verified her errata for *Publ. L. O.*, Vol. VII, pages 171 (found here but not published) and 476.

With reference to the erratum *L. O. B.*, page 275, I am quite sure that Dr. GLANCY is correct since the mean of the dates of observation as printed is June 19.5 and not 18.5. Since Dr. ALTER is now a lieutenant in the Coast Artillery and Adjutant to the Commander at Ft. Scott, and since his papers are all packed, reference to his computations cannot be made at this time.

With reference to the statement *L. O. Publ.*, Vol. VII, page 462, it may be pointed out that the hypothesis of perturbations by *Mars* was abandoned, as is pointed out in *L. O. Bulletin*, page 275, in the following words: "Any effect due to perturbation would be very much smaller than the uncertainty due to range."

The original statement in Vol. VII was made entirely on the basis of the previously known orbits before any computation was undertaken here. While the uncertainty of the orbit was recognized at that time, the enormous possible range of the elements became known only in the course of Dr. ALTER's computations. A condition of fairly close approach of *Aethra* to *Mars* within a comparatively short time after the original series of observation in 1873 might be produced by a proper choice of the mean motion and eccentricity within the range of solution. Thus perturbation by *Mars* may yet be a factor in this problem, although the possibility is remote. Of course, on the basis of the orbits involving identity with the Lowell object, no such approach can have occurred. But the large range of possible solutions would entirely obscure the effects of perturbation even if *Aethra* had been close to *Mars* while under observation instead of possibly approaching soon after, which is within the range of probability. The original statement in Vol. VII should therefore not be considered as erroneous, but as one worthy of consideration before the seemingly large range of practical solutions was found by Dr. ALTER's investigation.

If *Aethra* has not been subject to perturbations, the indeterminateness of the elements is sufficient to account for its loss, but it may also be subject to light variation. Furthermore the object may after all have been a comet moving in a highly elliptic orbit. Other cases are on record in which comets have been mistaken for asteroids on account of their star like appearance.

ON THE PREPARATION OF OBSERVATIONS FOR THE DETERMINATION OF A PRELIMINARY ORBIT BY THE METHOD OF LEUSCHNER.

By A. ESTELLE GLANCY.

The calculation of an orbit is simplified if the times of observation are Greenwich mean noon or midnight, and if the intervals are equal. If a graph of all the available observations were drawn on a large scale and a smooth curve passed through them, we could read off α_1, δ_1, α_2, δ_2, α_3, δ_3, for any chosen dates. In practice the accuracy of such positions is less than that of the original observations.

I have just completed such a curve preliminary to the determination of an elliptic orbit for the planet *1903 NF*, and have used a simple way to improve these positions.

The only available observations for this planet are 1903, Dec. 11, 15, 17, 18. From the Curve I read off the positions for the three dates, Dec. 12.0, 15.5, 19.0. To test the accuracy of these places the interpolations for the dates of observation were made. The comparison was not satisfactory so the following method of correction was used.

For simplicity take this particular case of three geocentric positions read from a smooth curve. It is necessary to assume the second difference constant. Suppose the comparison between the interpolated value for Dec. 11 and the observed value leaves a residual v in the sense O — C. Let f, f^{I}, f^{II}, represent those particular values of the function, the first difference and the second difference which were used in the interpolation. Then the residual is made up as follows:

$$\text{corr. to } f + n \text{ corr. to } f^{I} + \frac{n\,(n-1)}{2} \text{ corr. to } f^{II} = v$$

There will be as many equations as there are observations. The differences can always be simply expressed in terms of the functions themselves. Hence we shall have equations of the form:

$$\begin{array}{llll}
a_1 \text{ corr. to } f(a) & + \; b_1 \text{ corr. to } f(a+w) & + \; c_1 \text{ corr. to } f(a+2w) & = v_1 \\
a_2 & b_2 & c_2 & v_2 \\
a_3 & b_3 & c_3 & v_3 \\
 & \cdot & \cdot & \cdot \\
 & & \cdot & \cdot
\end{array}$$

Solving these equations and applying the corrections to the values from the curve, we have the improved values. With these the interpolations for the times of observation should be repeated, and if the comparison O — C is within the error of observation and the neglected third differences, the solution is correct and the normal places are ready for use.

This process can be extended to a larger number of observations, including a term for the neglected third difference, if desirable. In fact it is a method of setting up normal places without the aid of an ephemeris.

No account is here taken of parallax. The usual procedure is followed until the geocentric distance is known.

Given the geocentric distance all the observations could be corrected for parallax and the condition equations could be solved again to remove the parallax. But this is not necessary. Since it is customary in this method to neglect the effect of parallax upon the velocities and accelerations, the condition equations reduce simply to the relation that the correction to the normal is the correction for parallax. But, if the same function was used to interpolate the places for several dates, the correction to the normal is the mean of the parallax corrections, for which interpolated values of ρ can be used if necessary. The procedure is the same for the first and third places, but it is delayed until the representation of the first and third places, as usual.

To test the accuracy of the result the original observations as well as the normals have been represented by means of the f and g series. The residuals are:

1903	$\Delta\alpha \cos\delta$	$\Delta\delta$
Dec. 11.7	+10″	−2″
12.0	+ 6	+4
15.5	− 1	+3
15.7	0	0
17.7	− 7	+2
18.8	− 6	+2
19.0	− 7	+2

The residuals for the middle normal place are due entirely to accumulation. No differential correction was made to remove these residuals owing to the approximate nature of the first observation. The orbit is published elsewhere in these publications.

This experiment leads me to think that in some cases such normal places would be preferable to three single observations. In the present instance there were two advantages: (1) all the available observations were used; (2) the computations which were not done in duplicate were simplified and therefore less liable to error. The preparation of observations can be much shortened, if in place of making a graph, the positions for the chosen dates are interpolated directly from the given observations, estimating the second differences if necessary.

Observatorio Nacional, Cordoba,
June 10, 1917.

STELLAR PARALLAXES

DERIVED FROM PHOTOGRAPHS MADE WITH THE 60-INCH REFLECTOR OF THE MOUNT WILSON SOLAR OBSERVATORY,

By A. van MAANEN.

The following table gives a summary of the results obtained in the Mount Wilson parallax work. The full details for the individual stars, together with a discussion of the means employed, have been published in: *Proc. Nat. Acad. Sci.*, Vol. I, 187, 1915 and Vol. 3, 133, 1917; *Mt. Wilson Communications*, Nos. 6 and 40; *Mt. Wilson Contr.* Nos. 111 and 136. This last publication which is still in press also contains a discussion of systematic errors in the results. The conclusion derived is that there is no reason to suppose that the systematic error in the Mount Wilson parallaxes surpasses 0″.003.

The table needs little explanation. The magnitudes are taken from the *Revised Harvard Photometry;* exceptions are those of the components of the double stars, for which the difference in magnitude, as given in Burnham's *General Catalogue*, is added to the magnitude of the principal star, and the two Wolf-Rayet stars, for which the magnitudes are those given in the *Bonner Durchmusterung.* The spectra have been determined by Mr. Adams, (for notations like Ma (G6), see W. S. Adams *Proc. Nat. Acad. Sci.*, Vol. II, 163, 1916; *Mt. Wilson Communications*, No. 26). The proper-motions are from Boss's *Preliminary General Catalogue.* The column headed π contains the relative parallaxes. To convert these into absolute parallaxes about 0″.002 should be added. The mean probable error is less than 0″.006; the mean number of exposures is 15; the mean number of comparison stars is 8.

Star		α 1900	δ 1900	No. B.D.	Mg.	Sp.	μ	π	P.E.	No. Exp.	No. Comp. St.
		h m s	° ′	°			″	″	″		
Boss *P.G.C.*	96	0 26 13	+52 17	+52 92	5.69	K_0	0.056	+0.006	0.005	16	8
	106	0 27 33	+27 44	+27 84	6.38	G_6	0.014	+0.003	0.007	14	6
	178_1	0 44 31	+27 10	+26 131	6.29	F_0	0.092	+0.009	0.004	16	8
	178_2	0 44 31	+27 10		6.29	F_0	0.092	+0.007	0.003	16	8
	420	1 47 17	+40 14	+40 394	5.63	K_2	0.009	+0.004	0.007	14	8
	592	2 31 12	+24 13	+24 375	7.37	F_6	0.152	+0.008	0.015	14	8
	593	2 31 14	+24 13	+24 376	6.57	F_4	0.140	+0.028	0.014	14	8
	637	2 43 3	+68 28	+68 200	6.23	F_5	0.016	+0.008	0.003	18	7
	672	2 53 3	+46 49	+46 669	5.61	G_3	0.035	−0.009	0.001	14	9
	933	3 58 23	+23 50	+23 609	5.67	F_{5p}	0.022	+0.012	0.004	14	8
	1014	4 16 30	+20 35	+20 744	6.11	Ma (G_6)	0.011	−0.001	0.007	16	7
	comp	4 16 30	+20 35	. . . . .	9.21	. . . .	. . . .	−0.002	0.006	16	7
	1549	6 6 15	+22 56	+22 1220	6.30	Ma (G_4)	0.027	+0.001	0.001	16	9
	1868	7 9 42	+28 4	+28 1350	5.87	Ma (G_2)	0.020	+0.006	0.003	16	9
	1971	7 26 2	+17 18	+17 1596	5.64	K	0.089	−0.002	0.007	18	10
	2020	7 36 25	+14 27	+14 1729	5.81	Mb (G_5)	0.015	+0.004	0.005	14	8
	2285	8 30 32	+ 6 58	+ 7 1997	6.04	F_8	0.195	+0.020	0.005	16	9
	2286	8 30 32	+ 6 58		7.15	G_2	0.201	+0.024	0.008	16	9
	2338	8 39 13	+31 4	+31 1876	6.14	G_3	0.020	+0.005	0.003	12	5
	2528	9 20 0	+17 1	+17 2078	6.27	K_0	0.079	+0.013	0.003	18	8
	2603	9 35 53	+26 22	+26 1991	6.43	K_1	0.049	+0.010	0.005	16	7
	2881	10 43 26	+29 57	+30 2072	6.29	G_9	0.103	+0.034	0.002	12	7
	2921	10 53 58	+36 38	+36 2139	6.22	Ma (G_9)	0.095	+0.077	0.006	10	5
	3078	11 36 22	+32 18	+32 2179	5.74	F_2	0.347	+0.040	0.008	16	6
	3233	12 20 13	+24 29	+24 2455	6.08	G_9	0.072	+0.003	0.010	12	8
	3398	13 1 31	+23 9	+23 2538	5.90	Mc (G_8)	0.065	+0.041	0.009	12	5
	3650	14 9 17	+13 26	+13 2764	5.54	F_7	0.267	+0.095	0.003	12	9
	3736	14 33 35	+18 44	+18 2906	5.98	K_0	0.096	+0.055	0.005	16	5
	3816	14 52 26	+ 0 14	+ 0 3277	5.71	K_1	0.068	+0.042	0.006	14	6
	3867	15 7 31	+19 21	+19 2935	5.98	Mb (G_6)	0.004	+0.003	0.006	29	6
	4048	15 50 10	+20 36	+20 3166	5.76	K_3	0.083	+0.038	0.010	10	9
	4130	16 8 19	+ 5 17	+ 5 3165	5.64	K_3	0.046	+0.006	0.006	16	8
	4262	16 40 51	+15 56	+16 3013	5.78	Mb (G_9)	0.054	+0.020	0.004	16	7
	4307	16 50 37	+21 7	+21 3002	5.48	G_6	0.059	−0.001	0.005	16	8
	1393	17 14 53	+28 56	+28 2719	5.78	G_8	0.045	+0.013	0.005	12	9
	4480	17 36 59	+24 34	+24 3225	6.46	K_1	0.052	+0.018	0.003	16	9
	comp	17 36 59	+24 34	. . . . .	8.76	. . . .	. . . .	+0.022	0.008	16	9
	4555	17 57 5	+45 30	+45 2638	5.92	K_5	0.044	+0.024	0.004	18	10
	4629	18 15 4	+24 24	+24 3381	5.49	K_1	0.016	0.000	0.004	16	10
	4647	18 17 36	+51 18	+51 2357	6.25	K_0	0.062	+0.031	0.008	14	7
	4860	19 1 9	+31 36	+31 3453	5.80	K_4	0.085	+0.024	0.006	16	8
	1892	19 9 30	+49 40	+49 2959	6.84	G_4	0.630	+0.044	0.003	16	7
	4893	19 9 30	+49 40		6.62	G_4	0.655	+0.042	0.004	16	7
	5043	19 40 25	+41 32	+41 3469	6.04	K_4	0.017	+0.004	0.004	12	8
B.D. +35°	1001	20 6 29	+35 53	+35 4001	8.5	O	. .	+0.011	0.005	16	8
B.D. +35°	4013	20 8 8	+35 54	+35 4013	8.0	O	. .	+0.002	0.003	14	8
Boss *P.G.C.*	5184	20 9 57	+61 47	+61 1983	5.72	F_5	0.155	+0.035	0.004	14	8
	5210	20 14 34	+40 25	+40 4103	5.82	B_7	0.011	+0.006	0.002	12	10

Star	α 1900	δ 1900	No. B.D.	Mg.	Sp.	μ	π	P.E.	No. Exp.	No. Comp. St.
	h m s	°	°				″	″		
Boss *P.G.C.* 5433	21 2 25	+38 15	+38 4343	5.57	K_7	5.278	+0.325	0.011	18	8
5434	21 2 26	+38 15	+38 4344	6.28	K_8	5.155	+0.320	0.008	12	8
5519	21 23 52	+31 47	+31 4462	5.71	F_1	0.134	+0.030	0.004	18	8
5682	22 1 19	+82 23	+82 673	6.49	F_7	0.143	+0.003	0.008	16	6
5683	22 1 56	+82 23	+82 674	6.89	G_2	0.144	+0.005	0.007	16	6
5691	22 2 43	+18 59	+18 4930	5.78	F_2	0.127	+0.011	0.008	16	8
5772	22 18 51	+20 21	+20 5139	6.13	F_5	0.337	+0.058	0.007	16	7
5868	22 39 34	+38 56	+38 4855	6.12	K_4	0.016	+0.009	0.011	12	9
comp	22 39 34	+38 56	....	8.32	....	...	−0.003	0.008	12	9
5989	23 12 9	+52 40	+52 3410	5.65	F_9	0.270	+0.047	0.004	20	10
N.G.C. 7662	23 21 6	+41 59	+41 4773	...	Plan. Neb.	...	+0.021	0.004	16	8
Boss *P.G.C.* 6097	23 39 56	+55 15	+55 3010	6.62	G_6	0.029	+0.006	0.006	14	8

Mt. Wilson Solar Observatory, August, 1917.

OBSERVATIONS OF *RW CYGNI*,

By W. DOBERCK.

The first column of the following table shows the Julian Date −242 0000. The second column shows the comparisons between the magnitudes of *RW Cygni* and surrounding stars. The magnitudes of the comparison stars a(8.11), b(8.36), c(8.46), d(8.76), e(9.11), and f(9.18) have been taken from the *Annals of the Harvard College Observatory*. The magnitudes of the comparison stars A(7.04), B(7.43), C(7.44), D(7.47), and E(7.49) have been determined from estimations. A was compared 6, B 7, C 6, D 4, and E 14 times. A is *A. S. V.*, Series IV (7351), Num. 5, B 12, C 8, D 11, and E 9. That so many new stars were accidentally compared tends to increase the probable error of the observations. The third column of the table shows the magnitude deduced from the second column. The probable error of one observation is ±0.11, but this includes errors of the formula and any small irregularities in the star's brightness.

The period was found to be above 600 days. Comparison with PARKHURST's observations made in 1896 and 1897 furnished the value 631 days. The epoch of maximum (7.60) is 242 1088 +631 E, where E is the number of periods. The epoch of minimum (8.85) is 242 1413. It occurs 325 days after the maximum. At any other time the magnitude is found from the formula:

$$\text{Mag.} = 8.24 - 0.60 \cos x + 0.03 \sin (2x - 45^\circ) - 0.02 \sin (3x + 64^\circ)$$

where $x = 360^\circ\ (t - t_0) : 631$, and t_0 is the epoch of maximum.

J. D.	Comp.	Mag.	J. D.	Comp.	Mag.	J. D.	Comp.	Mag.	J. D.	Comp.	Mag.
0347	$v = a$	8.11	0663	$a\ 2\ v$	8.31	0774	$c\ 4\ v\ 2\ d$	8.66	1183	$B\ 3\ v\ 2\ a$	7.81
0358	$C\ 5\ v\ 3\ a$	7.87	0664	$c\ 2\ v\ 3\ d$	8.58	0777	$c\ 3\ v\ 1\ e$	8.95	1198	$a\ 1\ v\ 5\ c$	8.17
0371	$E\ 6\ v\ 2\ a$	7.96	0691	$a\ 3\tfrac{1}{2}\ v\ 2\ d$	8.51	0788	$v = d$	8.76	1207	$D\ 5\ v\ 4\ d$	7.83
0374	$C\ 3\ v\ 3\ a$	7.78	0707	$c\ 1\ v$	8.56	0801	$d\ 2\ v\ 5\ f$	8.88	1239	$a\ 3\ v$	8.41
0384	$C\ 4\ v\ 4\ a$	7.77	0725	$b\ 3\ v\ 3\ d$	8.56	1040	$E\ 3\ v\ 5\ a$	7.72	1255	$c\ 3\ v\ 1\ d$	8.68
0398	$E\ 4\ v\ 3\ a$	7.84	0742	$d\ 1\ v$	8.86	1067	$A\ 1\ v\ 1\ B$	7.35	1377	$d\ 2\ v\ 1\ e$	8.99
0434	$v\ 3\ a$	7.81	0746	$c\ 3\ v\ 2\ d$	8.64	1075	$B\ 3\ v\ 5\ a$	7.68	1392	$e\ 2\ v\ 3\ f$	9.14
0468	$E\ 1\ v\ 5\ a$	7.59	0747	$c\ 2\ v\ 3\ d$	8.58	1120	$D\ 3\ v\ 3\ a$	7.79	1411	$d\ 1\ v$	8.86
0483	$E\ 1\tfrac{1}{2}\ v$	7.64	0750	$c\ 2\ v\ 1\ d$	8.66	1133	$B\ 3\ v\ 4\ a$	7.72	1432	$d\ 1\ v$	8.86
0506	$E\ 3\ v\ 3\ a$	7.80	0751	$c\ 3\tfrac{1}{2}\ v\ 2\ d$	8.65	1156	$C\ 3\ v\ 3\ a$	7.77	1473	$c\ 3\ v\ 2\ d$	8.64
0534	$E\ 4\ v\ 7\ a$	7.72	0761	$c\ 1\ v\ 2\ d$	8.56	1170	$B\ 3\ v\ 5\ a$	7.68	1484	$c\ 1\ v\ 4\ d$	8.52

Kowloon, Elgin Road., Sutton, Surrey, 17 September, 1917.

FOCAL LENGTH OF THE 40-INCH TELESCOPE OF THE YERKES OBSERVATORY,

By E. E. BARNARD.

From an investigation, which is not yet printed, of the focal length of the 40-inch object glass and the effect upon it of the very great temperature changes to which it is subjected from summer to winter, I have taken the following facts which may be of general interest.

In 1902 and 1903 I measured with a steel tape line the distance from the center of the outer surface of the crown (outer) lens to the focal plane of the micrometer wires. This distance was 746.7 inches (18966 mm.), with a temperature of 50° F. The distance from the center of the space between the two lenses (they are separated by 8.6 inches [218 mm.]) to the focal plane was 739.9 inches (18793 mm.). The focal length as determined by my micrometer measures of star distances used in the determination of the value of the micrometer screw is 762.0 inches (19354 mm.) at temperature 50° F. In 1912 I verified these last figures from a rough measure of a photograph with the 40-inch of the Heliometer are in *Perseus*.

From these results it would seem that the actual focus of the large lens must be measured from a point 22.1 inches (561 mm.) beyond the center of the space between the two lenses, or 15.3 inches (389 mm.) beyond (outside) the outer surface of the crown lens. In effective power, therefore, the 40-inch telescope is equal to a telescope from one to two feet longer than the length of the tube would indicate. The observations also give the value at the focus of the 40-inch, at temperature 50° F., of

$$1'' = 0.0037 \text{ inch}$$
$$= 0.0937 \text{ mm.}$$

Yerkes Observatory, 1917, October 24.

SEARCH EPHEMERIS OF ENCKE'S COMET FOR DECEMBER, 1917,

By FRANK E. SEAGRAVE.

Gr. Midnight	α	δ	Log r	Log Δ
1917	h m s	° ′ ″		
Dec. 3	22 47 35	+3 7 7	0.28726	0.20805
7	22 47 47	+2 57 33	0.27712	0.21239
11	22 48 33	+2 51 23	0.26652	0.21642
15	22 49 49	+2 48 49	0.25546	0.22002
19	22 51 34	+2 49 42	0.24384	0.22305
23	22 53 47	+2 53 55	0.23166	0.22550
27	22 56 24	+3 1 20	0.21884	0.22730
31	22 59 33	+3 12 1	0.20537	0.22841

The next perihelion passage occurs March 25.50, 1918.

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On the Orbit of (132) *Aethra*, by A. Estelle Glancy.
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Search Ephemeris of Encke's Comet for December, 1917, by Frank E. Seagrave.

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OBSERVATIONS OF COMETS,

MADE WITH THE 20-INCH EQUATORIAL OF THE CHAMBERLIN OBSERVATORY, UNIVERSITY PARK, DENVER, COLO.,

By HERBERT A. HOWE.

The observations were made with the Bruce micrometer. The $\Delta\alpha$ observations of Comet *Brooks* were made by the usual method of transits over fixed wires.

For Comet *Gale* all the observations were made with the hand-driven traveling wire, as described in *A. J.* 644, except as follows; in the first set on Nov. 9 there were twenty observations by the traveling wire, and ten by fixed wires; in the second set of Nov. 9 the observations were all taken with fixed wires. Fixed wires were used for all the observations of Nov. 12, and for all those of Dec. 14, and of all the succeeding dates. This was the first comet, it is believed, to be observed by the traveling wire method.

All the observations of Comet *Metcalf* were made with the motor-driven wire, it being the first comet to be thus observed.

The last observation of Comet *Brooks* on Sept. 21, 1911, was made by Miss Myrtle L. Richmond.

The reductions of the observations were made in duplicate and sometimes in triplicate by students in the University of Denver.

The chief computers were Lillian Andersen, Harold R. Baker, Gladys Boggess, Frances Hole, Rachel Isbell, Dora Louthan, Edith Lutton, Waldo H. Lyons, Marie Malcom, Esther Moles, Oscar B. Parrott, and Lucile Winn.

Date	Gr. M. T.	*	Comp.	$\Delta\alpha$	$\Delta\delta$	App. α	App. δ	log $p\Delta$ α	log $p\Delta$ δ	Red. to App. Pl. α	Red. to App. Pl. δ
				Comet *1911* V (Brooks)							
1911	h m s			m s	′ ″	h m s	° ′ ″			s	″
Aug. 4	11 47 37	1	20 , 8	+0 30.55	− 8 4.3	21 54 53.32	+30 14 40.7	9.234*n*	0.204	+2.31	+ 4.7
4	12 2 13	2	19 , 6	−2 11.45	− 4 36.1	21 54 52.15	+30 15 6.8	9.144*n*	0.186	+2.31	+ 4.7
5	9 53 9	3	20 , 6	+1 6.20	+ 3 42.2	21 53 3.51	+30 54 20.7	9.581*n*	0.379	+2.33	+ 4.9
5	10 2 7	4	20 , 6	+1 36.53	+11 36.0	21 53 2.84	+30 54 34.2	9.564*n*	0.361	+2.33	+ 4.9
6	15 8 58	5	20 , 8	−0 24.82	− 6 54.1	21 50 26.28	+31 48 7.8	9.479	0.256	+2.35	+ 5.2
6	15 21 57	6	20 , 8	−0 36.91	− 6 44.8	21 50 25.67	+31 48 22.9	9.513	0.284	+2.35	+ 5.2
7	15 18 37	7	20 , 6	−2 41.37	−13 11.4	21 48 9.49	+32 33 13.5	9.523	0.268	+2.36	+ 5.3
7	15 33 10	8	20 , 6	−2 49.51	−11 10.0	21 48 8.17	+32 33 41.4	9.556	0.301	+2.36	+ 5.3
13	15 38 37	9	20 , 8	−1 1.64	− 4 30.1	21 31 14.17	+37 21 31.5	9.661	0.301	+2.40	+ 6.4
13	15 50 41	10	20 , 6	−1 19.84	− 6 49.7	21 31 12.37	+37 21 55.6	9.677	0.338	+2.40	+ 6.4
14	15 36 2	11	20 , 6	−2 13.22	+ 4 6.6	21 27 47.61	+38 12 9.0	9.672	0.295	+2.41	+ 6.7
14	15 46 42	12	20 , 6	−2 18.56	+ 7 40.3	21 27 46.20	+38 12 30.5	9.686	0.330	+2.41	+ 6.7
15	15 35 4	13	20 , 8	−0 26.18	− 2 34.3	21 24 8.41	+39 3 32.6	9.686	0.296	+2.41	+ 6.9
15	15 47 23	14	20 , 6	+2 8.67	+ 0 16.9	21 24 6.28	+39 3 56.4	9.701	0.337	+2.41	+ 7.0
16	15 31 6	15	20 , 6	+2 58.24	+ 2 10.2	21 20 16.12	+39 55 24.3	9.696	0.288	+2.41	+ 7.2
16	15 47 21	16	30 , 6	+2 38.47	− 2 29.2	21 20 13.72	+39 56 3.2	9.715	0.344	+2.42	+ 7.2
18	15 45 1	17	20 , 8	−0 49.86	− 4 11.1	21 11 44.62	+41 11 35.6	9.740	0.355	+2.43	+ 7.8
18	15 54 41	18	20 , 8	−0 23.77	+ 2 42.4	21 11 42.31	+41 11 53.6	9.748	0.388	+2.43	+ 7.8
24	9 11 20	19	20 , 8	−0 46.37	− 0 38.7	20 41 2.12	+46 49 40.4	9.315*n*	9.915*n*	+2.36	+ 9.4

Date	Denver M.T	*	No. of Comp	Δα	Δδ	App. α	App. δ	log pΔ α	log pΔ δ	Red. to App. Pl. α	Red. to App. Pl. δ
					Comet 1911 V (Brooks) — Continued.						
1911	h m s			m s	′ ″	h m s	° ′ ″			s	″
Aug. 24	9 23 22	20	20 , 6	−2 58.79	+ 2 58.3	20 10 58.63	+46 50 8.1	9.288n	9.957n	+2.37	+ 9.1
25	7 56 52	21	20 , 6	−2 0.90	− 6 14.9	20 34 51.26	+47 10 10.3	9.599n	9.417n	+2.34	+ 9.7
25	8 11 11	22	20 , 6	+1 50.95	− 1 57.2	20 34 47.56	+47 10 42.3	9.559n	9.664n	+2.33	+ 9.7
26	8 52 33	23	19 , 8	+0 20.94	− 1 26.3	20 27 11.41	+48 34 50.4	9.358n	0.040n	+2.30	+10.0
26	9 12 57	24	20 , 6	+1 17.11	− 1 51.6	20 27 35.24	+48 35 36.2	9.230n	0.091n	+2.29	+10.0
28	7 53 0	25	20 , 6	+2 12.20	+ 0 5.8	20 12 58.02	+50 15 13.3	9.532n	9.999n	+2.20	+10.5
28	8 4 7	26	20 , 6	+2 1.12	− 6 9.7	20 12 54.16	+50 15 37.9	9.191n	0.018n	+2.21	+10.5
30	8 1 57	27	20 , 8	−0 49.12	+ 3 41.2	19 56 6.52	+51 52 36.1	9.406n	0.191n	+2.12	+11.1
30	8 12 42	28	19 , 6	−1 32.64	− 1 30.2	19 56 2.10	+51 52 55.9	9.346n	0.214n	+2.12	+11.1
Sept. 2	8 14 22	29	20 , 6	−2 22.79	−13 41.6	19 27 14.63	+54 3 10.0	8.977n	0.336n	+1.91	+11.8
2	8 51 35	30	20 , 6	−3 28.92	−13 59.2	19 26 58.89	+54 3 58.8	8.496	0.344n	+1.92	+11.9
4	8 31 21	31	20 , 8	−0 44.51	+ 0 21.3	19 5 33.61	+55 15 48.8	8.801	0.375n	+1.72	+12.0
4	8 48 19	32	20 , 8	−1 6.74	+ 4 19.6	19 5 25.65	+55 16 11.7	9.088	0.366n	+1.72	+12.0
5	11 6 21	33	20 , 8	+0 48.62	+11 38.6	18 52 48.92	+55 49 40.6	9.774	9.808n	+1.60	+12.0
5	11 18 40	34	20 , 6	−0 4.80	− 1 21.8	18 52 43.15	+55 19 55.6	9.795	9.618n	+1.60	+12.0
6	8 49 35	35	20 , 8	+0 42.88	+ 6 31.8	18 42 2.77	+56 13 40.3	9.376	0.359n	+1.50	+11.9
6	9 1 12	36	20 , 6	−2 21.80	+13 26.9	18 41 57.05	+56 14 1.1	9.413	0.341n	+1.51	+12.0
7	9 29 25	37	19 , 8	−0 47.54	+ 1 31.1	18 29 25.74	+56 36 50.6	9.628	0.219n	+1.38	+11.9
7	9 42 7	38	20 , 6	−3 29.97	+ 3 17.6	18 29 19.02	+56 37 1.1	9.666	0.205n	+1.10	+11.9
8	8 24 42	39	20 , 6	+1 36.52	+ 4 26.6	18 17 23.62	+56 53 51.7	9.128	0.366n	+1.25	+11.6
8	8 39 7	40	19 , 6	+3 14.84	+ 2 33.6	18 17 16.09	+56 54 6.9	9.502	0.342n	+1.24	+11.6
11	8 59 18	41	20 , 8	−1 15.38	− 3 41.1	17 37 53.02	+57 17 40.4	9.735	0.124n	+0.90	+10.9
11	9 14 0	42	20 , 6	−1 36.83	−11 9.8	17 37 44.72	+57 17 41.1	9.766	0.034n	+0.89	+10.9
18	8 54 9	43	20 , 6	+2 25.81	− 8 25.9	16 7 38.14	+55 10 13.2	9.868	0.064	+0.25	+ 6.4
18	9 5 16	44	20 , 8	−0 40.99	+16 29.2	16 7 32.61	+55 9 54.1	9.876	0.154	+0.28	+ 6.5
20	8 16 8	45	20 , 6	−1 41.54	− 4 59.4	15 44 39.77	+53 52 7.7	9.848	0.054	+0.19	+ 5.0
20	8 33 14	46	20 , 6	−0 8.10	− 2 12.5	15 44 31.50	+53 51 38.4	9.861	0.182	+0.18	+ 4.8
21	8 44 7	47	20 , 6	+4 59.01	−12 31.7	15 33 24.85	+53 5 47.6	9.867	0.340	+0.14	+ 3.8
21	8 56 46	48	20 , 6	+2 8.78	−17 28.1	15 33 18.86	+53 5 20.7	9.871	0.395	+0.14	+ 3.9
24	9 30 53	48	20 , 6	+1 53.04	−18 35.8	15 33 3.12	+53 4 13.0	9.877	0.518	+0.14	+ 3.9
22	10 18 15	49	20 , 6	+4 38.92	− 3 31.6	15 22 7.18	+52 13 14.9	9.853	0.682	+0.12	+ 2.9
22	10 27 25	50	20 , 6	−1 51.38	− 8 51.2	15 22 3.39	+52 12 53.6	9.848	0.701	+0.13	+ 3.3
25	8 48 49	51	20 , 6	+2 47.46	− 3 17.2	14 53 26.85	+49 30 7.5	9.842	0.588	+0.11	+ 0.8
25	9 1 7	52	20 , 6	+3 12.52	− 1 23.7	14 53 21.89	+49 29 35.5	9.841	0.618	+0.11	+ 0.8
27	8 11 51	53	20 , 6	−5 29.06	− 1 39.2	14 36 8.71	+47 27 25.7	9.825	0.574	+0.15	− 0.1
27	8 30 39	54	20 , 6	−1 18.35	−10 54.3	14 36 2.67	+47 26 36.7	9.824	0.620	+0.13	− 0.4
Oct. 2	7 48 51	55	20 , 6	+1 6.86	− 1 40.0	13 58 46.21	+41 41 29.8	9.778	0.683	+0.26	− 3.8
2	8 1 20	56	20 , 6	+2 36.18	− 5 53.5	13 58 42.59	+41 40 55.2	9.774	0.704	+0.26	− 3.8
3	6 41 33	57	20 , 6	−2 9.93	+11 52.1	13 52 31.43	+40 30 27.4	9.772	0.584	+0.29	− 4.1
3	6 58 41	58	20 , 6	+2 18.61	+12 35.4	13 52 28.03	+40 29 41.8	9.771	0.614	+0.30	− 4.3
6	7 18 17	59	18 , 6	−0 58.15	− 8 21.2	13 34 29.19	+36 36 23.2	9.743	0.718	+0.37	− 5.6
6	7 36 8	60	20 , 6	+1 5.40	−12 5.8	13 34 24.73	+36 35 29.1	9.736	0.743	+0.36	− 5.6
7	7 5 7	61	20 , 8	+0 20.32	− 6 24.3	13 29 6.74	+35 17 4.7	9.737	0.717	+0.39	− 5.9
7	7 23 7	62	20 , 8	+0 40.62	− 4 32.0	13 29 2.43	+35 16 8.8	9.730	0.742	+0.39	− 6.0
9	7 8 21	63	20 , 6	−1 16.28	+ 0 25.8	13 19 0.41	+32 33 13.3	9.715	0.752	+0.41	− 6.5
9	7 21 52	64	20 , 6	−2 51.43	+13 4.3	13 18 57.85	+32 32 28.1	9.707	0.768	+0.44	− 6.5
10	6 30 56	65	20 , 6	+1 16.15	+ 7 2.7	13 14 27.35	+31 11 53.1	9.719	0.720	+0.47	− 6.9
10	6 41 40	66	20 , 6	+2 23.10	−10 38.0	13 14 25.50	+31 11 15.7	9.716	0.733	+0.47	− 6.9

Comet *1911 V* (Brooks) — *Continued.*

Date Denver M. T.	*	No. of Comp.	Δα	Δδ	App. α	App. δ	log pΔ α	log pΔ δ	Red. to App. Pl. α	Red. to App. Pl. δ
1911 h m s			m s	′ ″	h m s	° ′ ″			s	″
Oct. 11 6 31 58	67	20 , 8	−0 23.11	− 5 9.3	13 10 1.36	+29 17 8.1	9.710	0.735	+0.50	− 7.1
11 6 46 48	68	20 , 6	+3 51.21	− 8 41.2	13 9 58.82	+29 16 17.4	9.704	0.752	+0.50	− 7.2
12 7 7 2	69	17 , 6	−1 59.24	− 0 13.8	13 5 46.75	+28 18 51.7	9.681	0.783	+0.52	− 7.3
12 7 18 56	70	10 , 3	+2 45.37	+12 10.1	13 5 10.48	+28 18 12.4	9.672	0.791	+0.54	− 7.1
13 6 58 43	71	20 , 6	−1 18.87	− 6 29.2	13 1 50.75	+26 53 18.5	9.676	0.783	+0.56	− 7.6
16 6 3 6	72	20 , 6	−2 43.69	+ 0.8	12 51 35.69	+22 31 17.1	9.680	0.757	+0.61	− 8.1
22 16 55 33	73	20 , 6	−1 37.25	−11 49.5	12 36 59.34	+12 45 12.0	9.664*n*	0.725	+0.74	− 8.0
22 17 6 52	74	20 , 6	−2 6.60	+ 1 18.0	12 36 58.59	+12 44 56.8	9.662*n*	0.719	+0.74	− 8.0
23 16 25 27	75	20 , 6	−1 58.96	− 5 40.6	12 35 42.79	+11 16 27.8	9.664*n*	0.710	+0.75	− 8.0
23 16 50 57	76	5 , 3	−3 51.74	− 9 33.1	12 35 41.39	+11 11 50.2	9.662*n*	0.729	+0.75	− 8.0
29 16 43 39	77	20 , 8	−0 37.28	+ 1 58.1	12 33 13.76	+ 2 22 31.6	9.619*n*	0.743	+0.81	− 7.6
29 16 58 15	78	20 , 6	−3 46.84	− 7 23.9	12 33 13.70	+ 2 21 37.1	9.643*n*	0.742	+0.83	− 7.7
30 17 28 13	79	19 , 6	−3 52.08	− 3 53.6	12 33 39.45	+ 0 55 0.0	9.622*n*	0.741	+0.84	− 7.6
30 17 44 34	80	19 , 8	−0 20.40	+11 43.8	12 33 39.94	+ 0 51 0.6	9.697*n*	0.744	+0.85	− 7.4
Nov. 2 17 12 10	81	20 , 6	+3 6.68	− 4 21.6	12 36 5.50	− 3 9 17.6	9.627*n*	0.757	+0.87	− 7.0
2 17 26 49	82	19 , 6	+5 11.66	− 6 39.4	12 36 5.81	− 3 10 6.2	9.616*n*	0.759	+0.87	− 7.0
3 17 12 21	83	20 , 6	−1 6.95	+ 1 1.7	12 37 15.58	− 4 27 34.3	9.626*n*	0.761	+0.86	− 7.0
3 17 21 39	84	19 , 6	−2 20.37	+ 1 23.9	12 37 15.72	− 4 28 4.5	9.618*n*	0.762	+0.85	− 7.1
5 17 6 5	85	20 , 8	+0 34.32	−11 6.4	12 40 0.98	− 6 58 11.4	9.628*n*	0.767	+0.87	− 6.9
5 17 30 40	86	26 , 9	+2 40.53	+ 1 19.1	12 40 2.77	− 6 59 25.8	9.607*n*	0.773	+0.87	− 6.8
6 17 2 15	87	20 , 8	+0 42.77	+ 1 18.6	12 41 35.85	− 8 10 36.2	9.631*n*	0.769	+0.88	− 6.8
6 17 16 46	88	20 , 6	+3 7.05	− 3 55.8	12 41 36.67	− 8 11 21.0	9.619*n*	0.773	+0.88	− 6.7
8 17 34 38	89	20 , 6	−3 34.94	− 5 12.4	12 45 7.25	−10 31 37.4	9.601*n*	0.786	+0.89	− 6.9
8 17 57 52	90	10 , 3	−7 11.29	− 8 32.2	12 45 8.80	−10 32 42.1	9.572*n*	0.794	+0.88	− 7.0
9 17 4 14	91	20 , 6	−1 35.48	−10 40.8	12 46 57.52	−11 37 4.4	9.629*n*	0.779	+0.91	− 6.8
9 17 16 17	92	19 , 6	+2 28.91	+ 3 5.6	12 46 58.84	−11 37 40.8	9.618*n*	0.784	+0.92	− 6.7
13 17 5 48	93	20 , 6	−3 28.85	+ 1 50.0	12 55 10.91	−15 46 20.8	9.629*n*	0.790	+0.94	− 6.9
13 17 19 14	94	15 , 6	−3 45.73	+ 4 40.5	12 55 12.39	−15 46 53.9	9.616*n*	0.797	+0.94	− 6.9
14 16 57 42	95	20 , 6	−1 29.96	+ 3 5.7	12 57 21.21	−16 44 2.5	9.636*n*	0.788	+0.95	− 6.8
14 17 6 39	96	20 , 6	−2 15.21	+ 1 22.2	12 57 22.04	−16 44 21.7	9.629*n*	0.793	+0.95	− 6.8
15 17 6 26	97	20 , 6	+0 54.35	− 3 47.3	12 59 35.30	−17 40 40.9	9.629*n*	0.795	+0.96	− 6.7
15 17 18 54	98	20 , 6	+3 7.62	− 2 27.8	12 59 36.55	−17 41 10.1	9.617*n*	0.802	+0.96	− 6.6
16 17 33 43	99	20 , 6	+0 10.26	− 7 56.8	13 1 53.17	−18 36 20.5	9.690	0.812	+0.96	− 6.7
16 17 43 33	100	19 , 6	−1 14.21	− 3 4.2	13 1 54.14	−18 36 47.3	9.587	0.817	+0.96	− 6.7
17 18 5 6	101	20 , 8	−0 32 74	+ 8 19.6	13 4 12.56	−19 30 41.1	9.554*n*	0.831	+0.96	− 6.6
17 18 11 59	102	10 , 3	−5 12.60	− 3 0.6	13 4 14.05	−19 31 4.0	9.542*n*	0.834	+0.95	− 6.8
19 17 29 45	103	20 , 6	−4 12.00	−11 48.4	13 8 15.79	−21 11 12.3	9.606*n*	0.818	+0.97	− 6.8
19 17 46 2	104	20 , 6	−3 18.88	− 7 35.4	13 8 47.71	−21 11 46.4	9.584*n*	0.827	+0.97	− 6.8
20 17 14 33	105	20 , 6	−5 9.88	− 4 28.8	13 11 4.12	−21 59 28.7	9.625*n*	0.810	+0.98	− 6.8
20 17 30 58	106	20 , 6	+1 51.78	− 6 38.7	13 11 4.80	−22 0 2.9	9.695*n*	0.821	+1.00	− 6.6
22 17 36 45	107	20 , 6	+2 33.72	+ 7 29.3	13 15 47.79	−23 34 3.5	9.598*n*	0.829	+1.03	− 6.5
22 17 46 55	108	20 , 6	+2 6.39	+ 5 32.4	13 15 48.62	−23 31 19.2	9.583*n*	0.835	+1.03	− 6.6
23 17 55 34	109	20 , 6	−0 9.37	− 3 21.8	13 18 10.37	−24 19 37.5	9.569*n*	0.842	+1.05	− 6.7
23 18 4 13	110	20 , 8	−0 18.19	− 8 23.5	13 18 10.85	−24 19 56.9	9.554*n*	0.847	+1.05	− 6.7
24 17 24 33	111	20 , 6	−2 4.66	− 0 53.9	13 20 28.02	−25 2 32.1	9.615*n*	0.825	+1.06	− 6.8
24 17 35 55	112	20 , 6	−3 5.22	−17 35.7	13 20 29.00	−25 2 49.7	9.599*n*	0.833	+1.06	− 6.9
27 18 1 13	113	20 , 6	+1 7.67	− 4 1.0	13 27 33.16	−27 8 17.2	9.558*n*	0.854	+1.11	− 6.8
27 18 10 4	114	20 , 6	+1 39.02	+ 0 39.0	13 27 33.76	−27 8 33.0	9.540*n*	0.859	+1.11	− 6.8

Date Denver M.T.		∗	No. of Comp.	Δα	Δδ	App. α	App. δ	log pΔ		Red. to App. Pl.	
								α	δ	α	δ
				Comet *1911 V* (Brooks)—*Continued.*							
1911	h m s			m s	′ ″	h m s	° ′ ″			s	″
Nov. 28	17 44 24	115	20 , 6	+2 28.35	+10 11.5	13 29 51.35	−27 47 22.5	9.587*n*	0.846	+1.12	− 6.7
28	17 59 15	116	20 , 6	+3 15.33	− 8 25.5	13 29 52.98	−27 47 17.2	9.561*n*	0.855	+1.12	− 6.7
29	17 19 5	117	20 , 6	−0 9.67	−10 39.4	13 32 7.90	−28 25 2.3	9.625*n*	0.830	+1.13	+ 6.8
29	17 28 58	118	20 , 6	−3 32.61	+ 6 44.1	13 32 9.16	−28 25 30.7	9.611*n*	0.838	+1.11	− 6.9
30	17 24 45	119	20 , 8	+0 44.59	+ 3 27.6	13 34 27.75	−29 3 0.3	9.617*n*	0.836	+1.13	− 6.8
30	17 41 36	120	20 , 6	+5 54.45	+ 3 12.0	13 34 29.34	−29 3 33.6	9.586*n*	0.850	+1.14	− 6.6
Dec. 1	17 47 23	121	20 , 6	−1 12.18	+ 3 55.4	13 36 47.86	−29 40 13.6	9.581*n*	0.851	+1.15	− 6.8
1	18 3 10	122	20 , 6	+2 46.38	+ 8 43.8	13 36 49.28	−29 40 42.0	9.551*n*	0.864	+1.16	− 6.6
3	17 41 21	123	20 , 6	+2 2.12	− 7 29.0	13 41 21.14	−30 51 1.6	9.591*n*	0.853	+1.20	− 6.8
3	17 51 2	124	20 , 6	−2 33.62	+ 4 52.8	13 41 22.08	−30 51 12.0	9.571*n*	0.860	+1.18	− 6.8
5	17 34 19	125	20 , 6	−4 4.68	− 3 14.7	13 45 51.42	−31 58 31.9	9.603*n*	0.852	+1.24	− 7.0
5	17 46 40	126	20 , 6	−3 21.01	+ 1 38.4	13 45 52.77	−31 58 50.8	9.581*n*	0.861	+1.24	− 7.0
7	17 50 50	127	20 , 6	+1 53.39	+ 4 53.5	13 50 20.25	−33 3 45.8	9.572*n*	0.867	+1.30	− 6.9
7	18 0 11	128	20 , 6	−4 11.78	+ 2 34.7	13 50 21.21	−33 3 55.6	9.552*n*	0.873	+1.29	− 7.1
11	17 44 12	129	20 , 6	−0 19.57	+ 7 54.0	13 59 2.54	−35 5 17.1	9.581*n*	0.869	+1.39	− 7.1
11	17 54 34	130	19 , 6	−2 19.30	− 1 17.1	13 59 3.50	−35 5 27.0	9.560*n*	0.876	+1.39	− 7.2
14	18 6 50	131	20 , 6	−0 2.85	+ 5 22.3	14 5 24.52	−36 30 33.6	9.525*n*	0.888	+1.45	− 7.0
14	18 15 4	132	9 , 4	+0 41.11	+ 3 36.4	14 5 25.25	−36 30 50.7	9.503*n*	0.893	+1.45	− 7.0
				Comet *1912 a* (Gale)							
1912											
Oct. 22	6 21 14	265	40 , 8	+1 2.34	− 8 34.3	15 54 12.80	+16 56 41.6	9.641	0.663	+0.86	− 6.2
22	6 37 37	266	40 , 8	+3 10.17	+ 9 13.6	15 54 13.50	+16 57 21.2	9.653	0.675	+0.86	− 6.3
23	7 5 59	267	40 , 8	−0 36.07	+11 13.8	15 55 13.15	+17 48 37.7	9.670	0.695	+0.85	− 6.1
23	7 15 52	268	40 , 8	+1 37.08	+11 13.8	15 55 13.45	+17 49 2.6	9.673	0.703	+0.85	− 6.1
24	6 6 45	269	40 , 8	+4 1.33	+ 1 39.2	15 56 7.77	+18 36 6.5	9.638	0.644	+0.83	− 6.2
24	6 21 52	270	40 , 8	+3 24.36	−15 54.2	15 56 8.63	+18 36 39.5	9.650	0.657	+0.82	− 6.4
25	6 9 50	271	40 , 8	−5 11.69	−13 18.3	15 57 3.51	+19 24 44.1	9.646	0.643	+0.80	− 6.3
25	6 21 1	272	40 , 8	+2 18.21	+ 0 41.0	15 57 3.41	+19 25 15.8	9.654	0.653	+0.82	− 5.8
Nov. 1	6 6 40	273	40 , 8	+2 53.19	+12 22.3	16 3 0.74	+24 42 42.8	9.675	0.623	+0.68	− 7.1
1	6 18 20	274	38 , 8	+2 48.75	+ 7 1.1	16 3 1.21	+24 43 4.1	9.682	0.637	+0.68	− 7.1
5	5 48 58	275	40 , 8	−1 46.84	− 0 14.5	16 6 14.83	+27 30 50.5	9.682	0.593	+0.59	− 7.4
5	6 0 44	276	40 , 8	+0 32.01	− 5 6.6	16 6 15.43	+27 31 9.5	9.689	0.609	+0.59	− 7.5
7	6 8 13	277	40 , 8	−2 1.94	− 3 59.4	16 7 53.18	+28 53 15.5	9.702	0.618	+0.55	− 7.6
7	6 17 31	278	40 , 8	−2 22.39	− 3 39.3	16 7 53.66	+28 53 30.5	9.705	0.632	+0.55	− 7.6
9	5 49 24	279	30 , 8	+3 20.29	+ 8 44.2	16 9 31.12	+30 13 28.6	9.701	0.588	+0.52	− 8.3
9	6 1 36	280	20 , 8	+2 20.85	+ 9 40.4	16 9 31.70	+30 13 47.9	9.707	0.608	+0.52	− 8.2
12	6 1 40	281	20 , 8	+1 58.50	− 1 54.3	16 12 3.42	+32 13 10.2	9.720	0.607	+0.44	− 8.8
12	6 16 11	282	20 , 8	+4 32.90	− 0 8.6	16 12 3.99	+32 13 35.1	9.725	0.631	+0.45	− 9.0
14	6 1 27	283	40 , 8	+1 44.06	−0 39.73	16 13 47.40	+33 32 9.0	9.729	0.608	+0.40	− 9.3
14	6 15 31	284	40 , 8	+4 23.43	+ 5 1.9	16 13 47.80	+33 32 32.3	9.732	0.631	+0.40	− 9.5
16	5 45 53	285	40 , 8	−1 44.72	+ 0 20.9	16 15 33.86	+34 50 27.5	9.732	0.580	+0.34	− 9.5
16	5 51 54	286	40 , 8	−2 21.76	+ 0 10.0	16 15 34.08	+34 50 42.0	9.735	0.597	+0.34	− 9.4
18	5 44 48	287	40 , 8	−2 13.73	+ 2 30.2	16 17 24.01	+36 9 14.2	9.741	0.578	+0.30	−10.3
18	5 54 13	288	40 , 8	−3 59.03	− 4 8.2	16 17 24.60	+36 9 23.3	9.744	0.596	+0.28	− 9.7
22	5 55 8	289	40 , 8	+0 23.85	− 2 44.6	16 21 17.27	+38 47 42.1	9.762	0.601	+0.19	−11.0
22	6 5 53	290	50 , 8	+0 5.90	+ 7 27.3	16 21 17.74	+38 48 3.8	9.763	0.622	+0.20	−10.9
23	5 50 18	291	40 , 8	−3 7.59	− 1 8.6	16 22 18.13	+39 27 29.6	9.766	0.592	+0.17	−11.4
23	6 0 59	292	40 , 8	+2 6.55	+ 4 46.6	16 22 18.49	+39 27 48.0	9.767	0.614	+0.17	−11.3

Date Denver M.T.	*	No. of Comp.	Δα	Δδ	App. α	App. δ	log pΔ α	log pΔ δ	Red. to App. Pl. α	Red. to App. Pl. δ
					Comet *1912 a* (Gale) — (*Continued.*)					
1912 h m s			m s	′ ″	h m s	° ′ ″			s	″
Nov. 27 5 45 33	293	40 , 8	+0 49.00	+ 1 29.3	16 26 33.98	+42 8 47.1	9.781	0.586	+0.02	−12.2
27 5 55 39	294	10 , 8	−2 4.48	−11 30.4	16 26 31.97	+12 9 19.8	9.785	0.608	+0.00	−11.9
29 5 54 8	295	10 , 8	+1 1.46	−12 11.0	16 28 51.66	+13 31 3.9	9.795	0.606	−0.07	−12.8
29 6 5 53	296	40 , 8	−3 35.38	− 5 14.5	16 28 51.93	+43 31 25.5	9.794	0.631	−0.08	−12.3
Dec. 2 5 59 23	297	10 , 8	−1 56.69	− 3 38.6	16 32 28.83	+45 36 33.9	9.810	0.621	−0.19	−13.3
2 6 10 30	298	10 , 8	−3 52.42	− 8 51.8	16 32 29.47	+45 36 57.4	9.808	0.645	−0.20	−13.0
9 5 59 13	299	10 , 8	+0 56.24	+11 54.0	. . . . . .	. . . . . .	9.850	0.628	−0.53	−15.0
9 6 12 58	300	10 , 8	+3 19.19	+12 49.8	16 42 1.50	50 40 16.5	9.845	0.658	−0.51	−15.3
11 5 44 37	301	10 , 8	+3 12.09	+ 5 17.1	16 45 2.86	+52 9 57.0	9.866	0.593	−0.66	−15.8
11 5 54 47	302	40 , 8	−3 26.98	− 9 16.6	16 45 3.74	+52 9 56.4	9.864	0.618	−0.72	−15.0
14 5 57 31	303	20 , 8	+3 58.03	+ 8 7.7	16 49 58.64	+54 28 2.2	9.884	0.626	−0.87	−16.6
27 6 6 48	304	20 , 8	−1 41.33	+ 9 45.6	17 18 2.19	+64 57 37.4	0.006	0.633	−2.63	−17.0
27 6 25 56	305	15 , 8	+2 13.77	+ 6 32.4	17 18 4.92	+64 58 17.7	9.993	0.679	−2.60	−17.6
31 6 34 41	306	20 , 8	−1 49.33	+ 7 36.2	17 30 26.01	+68 18 42.4	0.011	0.685	−3.57	−16.7
31 6 53 18	307	20 , 8	+3 50.47	+ 2 33.0	17 30 29.60	+68 19 21.0	0.022	0.724	−3.53	−17.6
1913 Jan. 1 7 37 5	308	20 , 8	+2 43.07	−11 51.4	17 34 8.77	+69 11 0.1	9.977	0.794	−3.47	−14.6
1 7 54 27	309	20 , 8	−1 54.84	− 9 2.5	17 34 10.83	+69 11 37.4	9.945	0.817	−3.52	−11.3
3 6 32 33	310	20 , 8	+1 12.49	+ 8 18.0	17 41 41.67	+70 48 51.0	0.093	0.665	−3.77	−11.6
3 6 44 2	311	20 , 8	−1 24.09	+ 5 44.1	17 11 44.00	+70 49 14.1	0.082	0.691	−3.81	−14.4
11 6 32 1	312	20 , 8	−0 47.92	−12 0.2	18 27 29.57	+77 18 2.3	0.281	0.570	−6.45	−13.6
11 6 46 3	313	10 , 4	−6 15.93	−10 7.0	18 27 35.14	+77 18 27.1	0.269	0.611	−6.52	−13.1
					Comet *1913 b* (Metcalf)					
Oct. 1 10 6 23	314	40 , 8	+3 25.47	− 1 36.3	23 35 58.71	+73 25 1.3	9.520*n*	0.678*n*	+4.07	+21.6
1 10 26 8	315	40 , 8	−3 42.36	− 7 57.5	23 35 33.85	73 23 32.8	9.286*n*	0.686*n*	+4.20	21.4
2 8 59 27	316	40 , 8	−4 52.78	−18 53.1	23 9 54.03	71 27 54.6	9.714*n*	0.625*n*	+3.62	22.5
4 10 49 27	317	40 , 8	−2 51.12	+ 8 4.2	22 27 25.50	66 20 32.9	9.560	0.561*n*	+2.74	24.0
4 11 6 21	318	40 , 8	−2 24.88	+ 5 18.8	22 27 13.21	66 18 39.0	9.645	0.540*n*	+2.73	24.0
13 9 28 2	319	40 , 8	−1 37.41	+ 2 54.8	21 13 8.80	39 2 32.7	9.405	9.696	+2.25	22.4
13 9 45 2	320	40 , 8	−2 27.26	+12 18.2	21 13 6.36	39 0 24.7	9.165	9.813	+2.26	22.4
29 9 16 32	321	40 , 8	−4 6.92	− 7 54.4	20 47 10.58	5 25 4.0	9.509	0.709	+2.58	13.2
29 9 33 3	322	40 , 8	−4 20.04	− 9 48.8	20 47 10.33	5 24 10.6	9.538	0.712	+2.59	13.2

Mean Places of Comparison Stars for the Beginning of the Year

*	α	δ	Authority		*	α	δ	Authority	
	h m s	° ′ ″				h m s	° ′ ″		
1	21 54 20.46	+30 22 40.3	*A.G. Leiden*	9234	11	21 29 58.42	+38 7 55.7	*A.G. Lund*	18199
2	21 57 1.29	+30 19 38.2	*A.G. Leiden*	9268	12	21 30 2.35	+38 4 43.5	*A.G. Lund*	10200
3	21 51 54.98	+30 50 33.6	*A.G. Leiden*	9211	13	21 24 32.18	+39 6 0.0	*A.G. Lund*	10155
4	21 51 23.98	+30 42 53.3	*A.G. Leiden*	9203	11	21 21 55.20	+39 3 32.5	*A.G. Lund*	10129
5	21 50 48.75	+31 54 56.7	*A.G. Leiden*	9192	15	21 17 15.46	+39 53 6.9	*A.G. Lund*	10071
6	21 51 0.23	+31 55 2.5	*A.G. Leiden*	9198	16	21 17 32.83	+39 58 25.2	*A.G. Lund*	10076
7	21 50 48.50	+32 46 19.6	*A.G. Leiden*	9194	17	21 12 32.05	+41 15 38.9	*A.G. Bonn*	15265
8	21 50 55.32	+32 44 46.1	*A.G. Leiden*	9196	18	21 12 3.65	+41 39 3.4	*A.G. Bonn*	15254
9	21 32 13.41	+37 25 55.2	*A.G. Lund*	10223	19	20 41 46.13	+46 50 9.7	*A.G. Bonn*	14628
10	21 32 29.81	+37 28 38.9	*A.G. Lund*	10226	20	20 43 55.05	+46 47 0.4	*A.G. Bonn*	14666

*	α	δ	Authority	*	α	δ	Authority
	h m s	° ′ ″			h m s	° ′ ″	
21	20 36 19.82	+17 16 15.5	A.G. *Bonn* 14518	71	13 3 9.06	+26 59 55.3	A.G. *Cam.(Eng.)* 6359
22	20 32 54.28	+17 12 29.8	A.G. *Bonn* 14442	72	12 54 18.71	+22 31 54.4	A.G. *Berlin B* 4651
23	20 27 18.17	+18 39 6.7	A.G. *Bonn* 14316	73	12 38 35.85	+12 57 39.5	A.G. *Leipzig I* 4653
24	20 25 45.84	+18 37 20.8	A.G. *Bonn* 14272	74	12 39 4.15	+12 10 46.8	A.G. *Leipzig I* 4657
25	20 10 13.62	+50 14 57.0	A.G. *Cam.(U.S.)* 6414	75	12 37 11.00	+11 22 16.4	A.G. *Leipzig I* 4651
26	20 10 47.53	+50 21 37.1	A.G. *Cam.(U.S.)* 6423	76	12 39 32.38	+11 24 31.3	A.G. *Leipzig I* 4659
27	19 56 53.82	+51 18 40.8	A.G. *Cam.(U.S.)* 6302	77	12 33 50.20	+ 2 29 41.1	A.G. *Albany* 4529
28	19 57 32.62	+51 51 45.0	A.G. *Cam.(U.S.)* 6309	78	12 36 59.71	+ 2 29 9.0	A.G. *Albany* 4539
29	19 29 35.51	+51 16 39.7	A.G. *Cam.(U.S.)* 6069	79	12 37 30.69	+ 0 59 1.2	A.G. *Albany* 4540
30	19 30 25.89	+51 17 46.1	A.G. *Cam.(U.S.)* 6075	80	12 33 59.49	+ 0 42 21.2	A.G. *Albany* 4530
31	19 6 16.40	+55 15 15.5	A.G. *Hels. G.* 10211	81	12 32 57.95	− 3 4 48.9	A.G. *Strassburg* 4637
32	19 6 30.67	+55 11 10.1	A.G. *Hels. G.* 10215	82	12 30 53.28	− 3 3 49.8	A.G. *Strassburg* 4629
33	18 51 58.70	+55 37 50.0	A.G. *Hels. G.* 10056	83	12 38 21.67	− 4 28 28.9	A.G. *Strassburg* 4659
34	18 52 46.35	+55 51 5.4	A.G. *Hels. G.* 10061	84	12 39 35.24	− 4 29 21.3	A.G. *Strassburg* 4665
35	18 41 18.39	+56 7 5.6	A.G. *Hels. G.* 9938	85	12 39 25.79	− 6 46 58.4	A.G. *Wien-Ottak.* 4628
36	18 44 17.34	+56 0 22.2	A.G. *Hels. G.* 9974	86	12 37 21.37	− 7 0 38.1	A.G. *Wien-Ottak.* 4623
37	18 30 11.90	+56 35 7.6	A.G. *Hels. G.* 9846	87	12 40 52.20	− 8 11 48.0	A.G. *Wien-Ottak.* 4634
38	18 32 46.69	+56 33 31.6	A.G. *Hels. G.* 9870	88	12 38 28.74	− 8 7 48.5	A.G. *Wien-Ottak.* 4625
39	18 15 45.85	+56 49 13.5	A.G. *Hels. G.* 9729	89	12 48 11.30	−10 26 18.4	A.G. *Wien-Ottak.* 4664
40	18 14 0.01	+56 51 21.7	A.G. *Hels. G.* 9713	90	12 52 19.21	−10 24 2.9	A.G. *Wien-Ottak.* 4682
41	17 39 7.50	+57 21 10.6	A.G. *Hels. G.* 9413	91	12 48 32.09	−11 26 16.7	A.G. *Cam.(U.S.)* 4637
42	17 39 20.66	+57 28 10.0	A.G. *Hels. G.* 9414	92	12 44 29.01	−11 40 39.7	A.G. *Cam.(U.S.)* 4621
43	16 5 12.08	+55 18 32.7	A.G. *Hels. G.* 8655	93	12 58 38.82	−15 48 3.9	A.G. *Washington* 4969
44	16 8 13.32	+54 53 18.4	A.G. *Hels. G.* 8686	94	12 58 57.18	−15 51 27.5	A.G. *Washington* 4972
45	15 46 24.12	+53 57 2.1	A.G. *Cam.(U.S.)* 4847	95	12 58 50.22	−16 47 1.4	A.G. *Washington* 4971
46	15 44 39.42	+53 53 46.0	A.G. *Cam.(U.S.)* 4839	96	12 59 36.30	−16 45 37.1	A.G. *Washington* 4976
47	15 28 25.70	+53 18 15.5	A.G. *Cam.(U.S.)* 4783	97	12 58 39.99	−17 36 46.9	A.G. *Washington* 4970
48	15 31 9.94	+53 22 14.9	A.G. *Cam.(U.S.)* 4792	98	12 56 27.97	−17 38 35.7	A.G. *Washington* 4957
49	15 17 28.11	+52 16 43.6	A.G. *Cam.(U.S.)* 4734	99	13 1 41.95	−18 28 17.0	*Weiss-Arg.* 10349
50	15 23 54.64	+52 21 41.5	A.G. *Cam.(U.S.)* 4756	100	13 3 7.39	−18 33 36.4	*Weiss-Arg.* 10360
51	14 50 39.28	+43 33 23.8	A.G. *Bonn* 9668	101	13 4 44.34	−19 38 54.1	*Weiss-Arg.* 10375
52	14 50 9.26	+43 30 58.4	A.G. *Bonn* 9663	102	13 9 25.70	−19 27 56.6	*Weiss-Arg.* 10421
53	14 41 37.62	+47 29 5.0	A.G. *Bonn* 9597	103	13 12 56.82	−20 59 17.1	*Weiss-Arg.* 10452
54	14 37 20.89	+47 37 31.4	A.G. *Bonn* 9563	104	13 12 35.62	−21 4 4.2	*Weiss-Arg.* 10451
55	13 57 39.09	+44 43 13.6	A.G. *Bonn* 9224	105	13 16 13.02	−21 54 53.1	*Weiss-Arg.* 10494
56	13 56 6.15	+44 46 52.5	A.G. *Bonn* 9207	106	13 9 12.02	−21 53 47.6	*Weiss-Arg.* 10449
57	13 54 41.07	+40 18 39.4	A.G. *Bonn* 9192	107	13 13 13.04	−23 41 26.3	*Weiss-Arg.* 10456
58	13 49 39.12	+40 17 10.7	A.G. *Bonn* 9159	108	13 13 41.20	−23 39 45.0	*Weiss-Arg.* 10463
59	13 33 30.67	+36 14 50.0	A.G. *Lund* 5830	109	13 18 18.69	−24 16 9.0	*Gould* 18215
60	13 32 58.96	+36 17 40.8	A.G. *Lund* 5828	110	13 18 27.99	−24 11 26.7	*Gould* 18221
61	13 28 46.03	+35 23 34.9	A.G. *Lund* 5802	111	13 22 31.62	−25 1 31.7	*Gould* 18308
62	13 28 21.42	+35 20 16.8	A.G. *Lund* 5798	112	13 23 33.16	−24 45 7.1	*Gould* 18328
63	13 20 16.25	+32 32 54.0	A.G. *Leiden* 4891	113	13 26 24.38	−27 4 9.4	A.G. *Cordoba II* 3386
64	13 21 48.81	+32 19 30.3	A.G. *Leiden* 4897	114	13 25 53.65	−27 9 5.2	*Gould* 18378
65	13 13 10.73	+31 4 57.3	A.G. *Leiden* 4870	115	13 27 21.88	−27 57 30.3	*Gould* 18416
66	13 12 1.93	+31 22 0.6	A.G. *Leiden* 4864	116	13 26 36.53	−27 39 15.0	*Gould* 18398
67	13 10 24.00	+29 52 21.5	A.G. *Leiden* 4858	117	13 32 16.44	−28 14 16.0	*Gould* 18520
68	13 6 7.11	+29 55 5.8	A.G. *Leiden* 4842	118	13 35 10.66	−28 32 7.9	*Gould Zones* 2019
69	13 7 45.47	+28 19 12.8	A.G. *Cam.(Eng.)* 6390	119	13 33 12.02	−29 6 21.4	*Gould* 18554
70	13 2 54.57	+28 6 9.7	A.G. *Cam.(Eng.)* 6356	120	13 28 33.74	−29 6 39.0	*Gould* 18449

*	α	δ	Authority		*	α	δ	Authority	
	h m s	° ′ ″				h m s	° ′ ″		
121	13 37 58.89	−29 11 2.2	*Gould*	18632	288	16 21 23.35	36 13 41.2	*A.G. Lund*	6736
122	13 31 1.74	−29 19 19.2	*Gould*	18560	289	16 20 53.23	38 50 37.7	*A.G. Lund*	6731
123	13 39 17.82	−30 43 25.8	*Gould*	18662	290	16 21 41.61	38 10 17.4	*A.G. Lund*	6733
124	13 43 54.52	−30 55 58.0	*Gould*	18767	291	16 19 10.37	39 28 19.6	*A.G. Lund*	6724
125	13 49 54.86	−31 55 13.2	*Gould*	18899	292	16 20 41.77	39 23 12.7	*A.G. Lund*	6729
126	13 49 12.54	−32 0 22.2	*Gould*	18886	293	16 25 44.96	42 1 30.0	*A.G. Bonn*	10552
127	13 48 25.36	−33 8 32.4	*Wash. Zones*	11419	294	16 28 39.15	42 21 2.1	*A.G. Bonn*	10587
128	13 54 31.70	−33 6 23.2	*Gould*	18993	295	16 27 50.27	43 43 57.7	*A.G. Bonn*	10575
129	13 59 20.72	−35 13 4.0	*Gould*	19081	296	16 32 27.39	43 36 52.3	*A.G. Bonn*	10616
130	14 1 51.41	−35 4 2.7	*Gould*	19142	297	16 34 25.71	45 10 25.8	*A.G. Bonn*	10638
131	14 5 25.92	−36 35 48.9	*Gould*	19207	298	16 36 22.19	45 46 5.2	*A.G. Bonn*	10659
132	14 4 42.69	−36 34 20.1	*Wash. Zones*	11691	299	16 41 5.	50 28.6	*Anonymous*	
265	15 53 9.60	17 5 22.1	*A.G. Berlin A*	5706	300	16 38 12.82	50 28 12.0	*A.G.Cam.(Mass.)*	5052
266	15 51 2.47	16 48 13.9	*A.G. Berlin A*	5694	301	16 41 51.43	52 4 55.7	*A.G.Cam.(Mass.)*	5068
267	15 55 48.37	17 37 30.0	*A.G. Berlin A*	5720	302	16 48 31.41	52 19 28.0	*A.G.Cam.(Mass.)*	5091
268	15 55 49.68	17 37 54.9	*A.G. Berlin A*	5721	303	16 46 1.18	54 20 11.1	*A.G.Cam.(Mass.)*	5083
269	15 55 5.61	18 34 33.5	*A.G. Berlin A*	5717	304	17 19 47.15	64 48 8.8	*A.G. Hels. G.*	9239
270	15 51 43.45	18 52 40.1	*A.G. Berlin A*	5700	305	17 15 53.75	64 52 2.9	*A.G. Hels. G.*	9210
271	15 53 51.02	19 38 8.7	*A.G. Berlin A*	5741	306	17 32 18.91	68 11 29.9	*A.G. Christiania*	2685
272	16 2 20.80	19 24 40.6	*A.G. Berlin A*	5752	307	17 26 42.66	68 17 8.6	*A.G. Christiania*	2664
273	16 0 6.87	24 30 27.6	*A.G. Berlin B*	5504	308	17 31 29.17	69 23 6.1	*A.G. Christiania*	2678
274	16 0 11.78	24 36 10.1	*A.G. Berlin B*	5505	309	17 36 9.19	69 20 54.2	*A.G. Christiania*	2705
275	16 8 1.08	27 31 12.4	*A.G. Cam.(Eng.)*	7531	310	17 40 32.95	70 40 47.6	*A.G. Berlin C*	2473
276	16 5 42.83	27 36 23.6	*A.G. Cam.(Eng.)*	7501	311	17 43 11.90	70 43 44.4	*A.G. Berlin C*	2483
277	16 9 54.57	28 57 22.5	*A.G. Cam.(Eng.)*	7547	312	18 28 23.94	77 30 16.1	*A.G. Kasan*	3112
278	16 10 15.50	28 57 17.4	*A.G. Cam.(Eng.)*	7548	313	18 33 57.59	77 28 47.2	*A.G. Kasan*	3127
279	16 6 10.31	30 4 52.7	*A.G. Leiden*	5705	314	23 32 29.17	+73 26 16.0	*A.G. Berlin C*	3388
280	16 7 10.33	30 4 15.7	*A.G. Leiden*	5709	315	23 39 12.01	+73 31 8.9	*A.G. Berlin C*	3411
281	16 10 4.48	32 15 13.3	*A.G. Leiden*	5727	316	23 14 43.19	+71 46 25.2	*A.G. Berlin C*	3339
282	16 7 30.64	32 13 52.7	*A.G. Leiden*	5713	317	22 30 13.88	+66 12 4.7	*A.G. Christiania*	3620
283	16 12 2.94	33 32 58.0	*A.G. Leiden*	5737	318	22 29 35.36	+66 12 56.2	*A.G. Christiania*	3615
284	16 9 23.97	33 27 39.9	*A.G. Leiden*	5722	319	21 14 43.96	+38 59 15.5	*A.G. Lund*	10039
285	16 17 18.24	34 50 16.1	*A.G. Leiden*	5766	320	21 15 31.36	+38 47 44.1	*A.G. Lund*	10048
286	16 17 58.50	34 50 41.4	*A.G. Leiden*	5770	321	20 51 14.92	+ 5 32 45.2	*A.G. Leipzig II*	10458
287	16 15 9.98	36 6 54.3	*A.G. Lund*	6702	322	20 51 27.78	+ 5 33 46.2	*A.G. Leipzig II*	10461

NOTES

Comet *1911 V* (Brooks)

1911	Aug.	4.	Good nucleus of magnitude 9; small coma.
		5.	Beautiful seeing; fine nucleus.
		6.	Nucleus still measurable at $16^h 0^m$.
		15.	Comet rather dim in haze and moonlight.
		24.	Comet bright, with fine nucleus.
		25.	Large coma around fine nucleus.
		26.	Comet's head large.
	Sept.	5.	Bad seeing; gusts of wind shook telescope.
		8.	Fine stellar nucleus.
		11.	Comet easily seen with naked eye in strong moonlight; magnitude about 4.5.
		18.	Comet conspicuous to naked eye; tail barely visible in five-inch finder.

1911 Sept. 20. A straight, narrow, faint tail projected away from the *Sun*, looking narrower than the head.
21. The third set of observations was made by Myrtle L. Richmond.
22. Comet of magnitude 3; fine nucleus and large head; declination of Cambridge 4756 increased by 1′.
25 and 27. Difficult to see the right ascension wires against the bright coma.
Oct. 3. Two jets streamed from the nucleus, neither being directly toward the *Sun*.
7. Nucleus elongated, but no jets seen.
13. Observations seriously affected by refraction at hour angle 7h 23m.
22. Head of magnitude 1 or 2; spreading tail 25 or 30 degrees long, slightly curved toward the north; nucleus fine.
30. Tail fainter than on Oct. 23. No fixed star visible to the naked eye when observations ended.
Nov. 3. Observations difficult because the wires were barely visible against the comet's tail.
6. Nucleus nicely defined; moonlight obliterates the tail, except near the head, where a short section was visible to the naked eye.
8. Observations terminated by strong twilight.
13. Wires poorly seen because of bright comet behind them.
17. Observations shortened by strong twilight.
24. Trouble with wind and variable refraction at low altitude.
27. Comet vanished in strong twilight soon after 18h 15m.
Dec. 3. Observations poor from sudden and violent changes of refraction at hour angle of 3 hours.
5. Strong moonlight; comet large, fluffy and difficult. Troubled with variable refraction at hour angle of 3h 2m.
7. Comet not plain this month, probably from low altitude; variable refraction bothers.
11. Nucleus distinctly visible for the first time in many days; definition astonishingly good for so low an altitude.
14. Observations terminated by twilight.

Comet *1912 a* (Gale)

1912 Nov. 1. The comet has a clear nuclear brightening.
7. Comet badly defined and faint.
9. The observation at 5h 49m 24s had 20 comparisons in right ascension by traveling wire, and 10 by fixed wires.
12. Comet well defined and easy to bisect.
14. Nucleus plain.
16. Bisections in right ascension poor.
27. Seeing very bad.
Dec. 11. Comet faint in twilight and haze.
14. Comet barely seen; too close to *A.G. Camb.* 5097, which finally obliterated it.
31. Seeing very poor.

Comet *1913 b* (Metcalf)

1913 Oct 1. Good nucleus.
13. Easily seen, though *Moon* is full.

CONTENTS.

Observations of Comets, by Herbert A. Howe.

Editor, Benjamin Boss, Albany, N. Y.; Associate Editors: E. E. Barnard, Ernest W. Brown, F. R. Moulton and R. S. Woodward.
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THE ORBIT OF Σ *2026 = B 7561*.

By GEORGE C. COMSTOCK.

All determinations of the orbit of this binary star known to me are summarized below in Table I, and it is evident from their disagreement that the case is a difficult one, perhaps not yet ripe for solution. Most of the investigators whose results are indicated in Table I designate them as very uncertain.

Table I.

Investigator	Last Obs.	L	B	a	P	Publication
		°	°	$''$		
Van Biesbroeck	1903	215	50	2.89	522y	*Annales Belg.*, IX
Lewis	1905	. .	. .	. . .	140	*Mem. R. A. S.*, 56
Aitkin	1912	198	18	1.56	163	*Pub. Lick O.*, XII
Matzdorff	1914	177	13	1.78	242	*Astr. Nach.*, 4823
Comstock	1917	175	5	1.53	215	*Ast. Jour.*, El. II

L and B denote polar coördinates of the periastron in a system having the line of sight as the axis of z. a and P denote the major axis and periodic time respectively.

The star's motion during recent years has been so rapid that, in ignorance of Matzdorff's work, I undertook a discussion of the available material, using for the earlier data the observations collected by Lewis and by Aitkin. For observations subsequent to 1900, I have examined all accessible sources and utilized all material there found but, unfortunately, Wirtz's Strassburg observations were discovered too late to be used. The observed position angles, θ (reduced to the epoch 1900.0), and the observed distances, s, were first plotted with the time as argument, smooth curves drawn through the plotted points and values of the double areal velocity, $s^2\, ds/dt$, derived from these curves. Within admissible limits of accidental error these values are constant and suggest no disturbing influence in the motion. I have therefore read from the curves at convenient intervals corresponding values of θ and s and from these find by a graphical process, the following elements of the star's motion:

Elements I

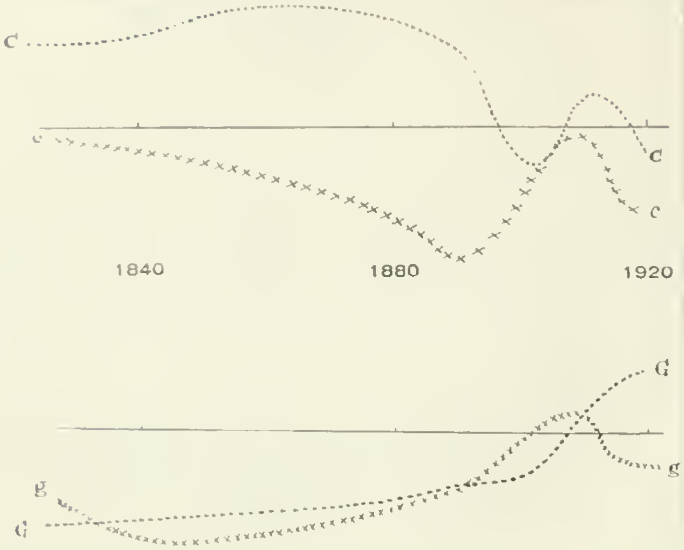
$$\left.\begin{aligned} \Omega &= 355^\circ.4 \\ \omega &= 172^\circ.8 \\ i &= 45^\circ.3 \end{aligned}\right\} 1900.0 \qquad \begin{aligned} T_0 &= 1908.4 \\ a &= 1.40 \\ P &= 180 \text{ years} \end{aligned}$$

$$e = 0.673$$

To determine how far these elements would be changed by a more rigorous treatment of the data, I have united the available observations into 19 normal places (see Table II) and have compared these with an ephemeris computed from Elements I, slightly modified by the addition of tentative corrections. The resulting differences, O — C, furnish the absolute terms of certain equations of the form.

$$A\Delta\Omega + B\Delta\omega + C\Delta i + D\Delta\varphi + Fn\Delta T + G\Delta n = \mathrm{O} - \mathrm{C}.\ \theta$$
$$h\Delta a + b\Delta\omega + c\Delta i + d\Delta\varphi + fn\Delta T + g\Delta n = \mathrm{O} - \mathrm{C}.\ s$$

from which corrections to the provisional elements are to be derived. The eccentric angle defined by $\sin\varphi = e$ is here introduced in place of the eccentricity. It has been a common practice among astronomers to determine from the position angles alone, values of the unknowns appearing in the first of these equations



and, ignoring these quantities in the second equation, to use it solely for the determination of the major axis, *a*. This procedure appears to me, at least in the present case, to be neither theoretically sound nor practically wise, since some of the unknowns appear in the second equation with coefficients quite comparable in magnitude with those affecting the corresponding quantities in the first equation. See the accompanying figure in which certain of these coefficients are shown graphically for the period covered by the available data. Note that the scales for the upper and lower half of the figure are not the same. I have constructed upon a large scale similar curves for all of the coefficients and have read from these the values to be employed in forming the equations corresponding to the several normal places. Treating separately the equations in position angle and distance, I have formed normal equations for each group and having eliminated $\Delta\Omega$ from the one group, Δa from the other, I have combined the resulting equations $[BB \cdot 1]$ $[bb \cdot 1]$, etc. into a single group whose solution furnished the adopted values of the remaining unknowns. The following comments relate to the process thus outlined.

Coefficients of the Observation Equations. The application of the method of least squares to homogeneous data leads to a result which makes the sum of the weighted squares of the residuals $[pvv]$ a minimum, but in the present case, the data are not homogeneous until the residuals in position angle have been transformed into arc of a great circle, *i.e.* in the first equation O — C must be construed to represent not $\Delta\theta$ but $s\,\Delta\theta \div 57.3$. The corresponding modification of the coefficients $\partial\theta/\partial\Omega$, $\partial\theta/\partial i$, etc., is taken into account in the following expressions which I have found more convenient for numerical application than any of the published forms with which I am acquainted. Adopting the conventional notation of elliptic motion, I introduce auxiliary quantities defined by the relations,

$$\mu = [8.2419]\, s \qquad\qquad \kappa = (2 + \sin\varphi \cos v) \sin E$$

$$\sigma = -\mu \tan i \sin(\theta - \Omega) \cos(\theta - \Omega)$$

and find the following expressions:

$A = +\mu$	$\Delta\Omega$	....
$B = +\mu \left(\frac{r}{s}\right)^2 \cos i$	$\Delta\omega$	$b = +\sigma \sin i$
$C = +\sigma$	Δi	$c = +\sigma \tan(\theta - \Omega)$
$D = +B \frac{a}{r} \kappa$	$\Delta\varphi$	$d = +b \frac{a}{r} \kappa - \mu \frac{a}{r} \cos\varphi \cos v$
$F = -B \left(\frac{a}{r}\right)^2 \cos\varphi$	$n\Delta T_0$	$f = -b \left(\frac{a}{r}\right)^2 \cos\varphi - \mu \left(\frac{a}{r}\right)^2 \sin\varphi \sin E$
$G = +F(T_0 - T)$	Δn	$g = +f(T_0 - T)$
......	Δa	$h = +\frac{s}{a}$

The absolute terms in the θ equations may be transformed from degrees into seconds of arc by multiplying them by the factor μ. The solution of the equations will then furnish Δa in seconds of arc and the other unknowns in degrees. To secure approximate equality among the coefficients it will frequently be advantageous to adopt as unknowns the desired corrections to the provisional elements multiplied by some convenient integer, *e.g.* a power of 10.

Weights. In the formation of normal places I have assigned unit weight to each annual mean result of each observer, unless such result was an observation upon one night only, in which case it received half weight. Approximately simultaneous results by different observers, if such were available, were united into a weighted mean result which appears in Table II, accompanied by its weight and an indication of the observers contributing to it. For explanation of the abbreviations of the observers' names see *Astr. Jour.*, No. 712. With reference to the well known difference in precision between observations of position angle and distance, the weight of each equation in distance as taken as one-half of the weight above described and entered in Table II.

The Equations and Their Solution: Pursuant to a suggestion made above, the unknowns actually introduced into the equations were defined by the following relations:

$$10x = \Delta\Omega \qquad 10w = \Delta\varphi$$
$$10y = \Delta\omega \qquad -10\mu = n\Delta T_0$$
$$50z = \Delta i \qquad t = \Delta n$$
$$q = 2\Delta a$$

An inspection of the equations formed with these unknowns shows, what is also apparent from a geometrical consideration of Elements I, that the data suffice to determine the sum $\Delta\Omega + \Delta\omega$ but are quite inadequate to discriminate between the two parts entering into this sum; *i.e.* the position of the periastron is fairly well determined, but not the route by which that position shall be reached in traveling from the prime meridian. I have put $y = o$ and thereby thrown the whole adjustment upon the node. Next among the elements in the order of uncertainty stands the periodic time, represented in the equations by n or t. The solution furnishes $P = 215 \pm 16$ yrs. Adopting this result I have derived for each other element its corresponding value together with a coefficient showing the change produced in it by a variation of one year in P. The elimination equations from which these quantities were derived are as follows:

ELIMINATION EQUATIONS

$$\begin{array}{rrrrrrrrrrl}
x & + & 1.86\,z & + & 0.82\,w & + & 1.05\,u & - & 1.51\,t & = & -0.057'' \\
q & - & 0.82\,z & + & 0.22\,w & + & 0.24\,u & - & 0.83\,t & = & -0.047 \\
 & & z & - & 0.08\,w & - & 0.51\,u & + & 0.08\,t & = & -0.089 \\
 & & & & w & - & 0.01\,u & - & 0.72\,t & = & -0.045 \\
 & & & & & & u & + & 0.28\,t & = & -0.029 \\
 & & & & & & & & t & = & +0.118
\end{array}
\qquad
\begin{array}{rcl}
x & = & +0.390'' \\
q & = & -0.047 \\
z & = & -0.127 \\
w & = & +0.040 \\
u & = & -0.062 \\
t & = & +0.118
\end{array}$$

The values thus derived furnish the adopted orbit, *viz.:*

ELEMENTS II

$$\begin{array}{rll}
\Omega = & 358.7 & +0.117\,\Delta P \\
\omega = & 172.8 & \ldots\ldots \\
i = & 44.1 & -0.031\,\Delta P \\
\varphi = & 44.0 & +0.056\,\Delta P \\
T_0 = & 1908.07 & -0.012\,\Delta P \\
P = & 215.0 & +1.000\,\Delta P \\
a = & 1.53 & +0.0023\,\Delta P \\
n = & -1.677 & \ldots\ldots\ldots
\end{array}$$

An ephemeris has been computed from these elements, compared with the adopted normal places of the star and the resulting residuals are shown in Table II. The sum of the weighted squares of these residuals is $[pvv] = 0.183$, and the solution of the normal equations gives $[nn \cdot 6] = 0.191$. Since the major part of the computation was carried to only two places of decimals the agreement between these numbers is as close as could be expected and furnishes a check upon the substantial correctness of the work. The addition to the data of the observations by WIRTZ, which were not included in the solution, gives to the residuals in position angle during the period 1908—1915 an apparently systematic character that might be mitigated by modifying the adopted value of T_0 or φ, but in view of the small distance between the stars at this epoch, $<0.''5$, I have not considered it worth while to make the change.

The following extract from the ephemeris computed from Elements II will suffice to test those elements through comparison with the observations of the next dozen years.

EPHEMERIS

Date	θ		s	
1916.0	96.0		0.49	
		14.2		7
18.	81.8		.56	
		11.5		7
20.	70.3		.63	
		9.2		8
22.	61.1		.71	
		7.3		9
24.	53.8		.80	
		5.9		9
26.	47.9		.89	
		4.7		9
28.	43.2		0.98	
		3.8		8
30.	39.4		1.06	
		2.9		8
32.	36.5		1.14	

Table II.

Comparison of Normal Places with the Adopted Elements.

Observers	Date	Wt.	Position Angle			Distance	
			Observed	O − C		Observed	O − C
			°	°	″	″	″
Σ	1830.94	1	345.6	+1.9 =	+0.08	2.54	+0.17
M^{h}_{A}	43.49	1	338.8	0.0	.00	2.25	+ .08
M^{h}_{A}, Sec	54.52	2	332.3	−1.2	− .04	1.95	− .03
Δ	67.63	2	325.2	0.0	.00	1.45	− .16
W. and S., G	74.59	1.5	317.5	−1.5	− .04	1.39	.00
Eng'l	83.70	1	311.8	+5.2	+ .10	1.27	+ .21
H Σ	89.19	2	293.6	−0.8	− .01	0.89	+ .03
Leav. A.	96.52	2	265.3	0.0	.00	0.67	+ .07
A. Bow., Brown	97.12	2.5	258.3	−2.0	− .02	0.58	.00
A. Bow	99.05	1.5	247.6	−2.2	− .02	0.62	+ .08
A. Bies.	1903.49	2	215.8	+1.1	+ .01	0.53	+ .05
Bies, Lewis	04.70	2.5	202.1	−2.0	− .02	0.66	+ .18
A. β	06.01	2.5	194.8	+2.3	+ .02	0.39	− .08
Bies, Lewis, Bow	07.47	2	183.4	+4.3	+ .04	0.44	− .02
Bies	08.37	1	169.1	−1.4	− .01	0.37	− .09
A. Bies	11.42	2	136.6	−3.9	− .03	0.36	− .08
Wirtz	11.52	0	136.6	−4.9	− .04	0.52	+ .08
A. Bies	12.50	2	128.8	−0.7	− .01	0.41	− .03
Wirtz	15.00	0	92.2	−12.5	− .10	0.52	+ .08
C.	15.03	2	101.4	−3.3	− .03	0.39	− .08
C	17.02	2	89.1	+0.9	+ .01	0.46	− .06

Washburn Observatory, October, 1917.

OCCULTATIONS OF STARS BY THE *MOON*.

OBSERVED WITH THE 26-INCH AND 12-INCH EQUATORIALS OF THE U. S. NAVAL OBSERVATORY.

[Communicated by Rear Admiral T. B. Howard, U. S. Navy, Superintendent.]

Date	Object	Phen.	Wash. Sid T.	Wash. M T.	See'g	Instrum't	Pow'r	Obs.	Remarks
			h m s	h m s					
Mar. 11	112 *B. Aurigæ*	DD	6 40 29.1	7 23 19.8	g	26-inch	183	H	Double star.
11	112 *B. Aurigæ*	RB	7 13 32.2	7 56 8.2	g	26-inch	250	H	Late.
11	112 *B. Aurigæ*, 1st. comp.	DD	6 40 21.1	7 23 5.5	g	12-inch	235	B	
11	112 *B. Aurigæ*, 2d comp	DD	6 40 29.5	7 23 10.9	g	12-inch	235	B	2d comp. pr. north of 1st comp.
11	112 *B. Aurigæ*	RB	7 13 28.6	7 56 4.6	g	12-inch	169	B	Could not separate components at reap.
16	18 *Leonis*	RB	5 29 54.9	5 53 8.4	p	12-inch	169	B	Daylight.
16	19 *Leonis*	RB	6 22 38.2	6 45 43.1	p	12-inch	169	B	
23	π *Scorpii*	DB	12 13 31.4	12 8 7.4	p	26-inch	250	H	
23	π *Scorpii*	DB	12 13 27.9	12 8 3.9	p	12-inch	160	B	Perhaps a little early. Haze.
23	π *Scorpii*	RD	12 56 1.6	12 50 33.6	f	12-inch	115	B	A little haze.
23	55 *B. Scorpii*	DB	16 58 19.8	16 52 39.0	g	26-inch	250	H	

Date	Object	Phen.	Wash. Sid. T.	Wash. M. T.	See'g	Instrum't	Pow'r	Obs.	Remarks
1916			h m s	h m s					
Mar. 23	65 *B. Scorpii* .	RD	18 6 39.9	18 0 18.0	f	26-inch	183	H	Late. Haze.
23	65 *B. Scorpii* .	DB	16 58 49.6	16 52 38.8	g	12-inch	160	B	A little haze.
24	95 *G. Ophiuchi* . .	DB	17 22 24.4	17 12 13.9	g	26-inch	250	H	Haze.
24	95 *G. Ophiuchi*	DB	17 22 24.0	17 12 13.5	g	12-inch	160	B	Grad. Haze. Dawn. Starfaint.
June 13	*b Scorpii* . .	DD	19 16 15.9	13 47 18.0	p	26-inch	388	B	
13	*b Scorpii* . . .	DD	19 16 16.4	13 47 18.5	vp	12-inch	235	ECB	Very late.
18	29 *Capricorni* . .	DB	19 44 36.3	13 55 54.2	f	26-inch	250	B	Gradual.
18	29 *Capricorni* . .	RD	21 0 56.4	15 12 1.8	f	26-inch	388	B	
18	29 *Capricorni* . .	DB	19 44 35.3	13 55 53.2	g	12-inch	160	ECB	Gradual.
18	29 *Capricorni* . .	RD	21 0 56.7	15 12 2.1	g	12-inch	160	ECB	0^{s}.2 late.
21	22 *Piscium* . . .	DB	20 51 33.4	14 50 52.7	p	26-inch	250	B	Gradual.
21	22 *Piscium* . .	RD	21 6 14.0	15 5 30.8	p	26-inch	250	B	Perhaps a little late.
22	136 *B. Piscium*	DB	21 51 31.3	15 46 44.8	f	26-inch	250	B	Gradual.
July 23	17 *Tauri* . . .	DB	21 40 3.0	13 33 25.1	p	26-inch	250	H	Uncertain. Haze.
23	23 *Tauri*	RD	23 1 5.6	14 54 14.4	g	26-inch	183	H	
23	23 *Tauri* . . .	RD	23 1 5.5	14 54 14.3	g	12-inch	160	B	G. reappearance. Haze.
23	*η Tauri*	DB	22 37 48.3	14 31 0.9	g	26-inch	250	H	
23	*η Tauri* . . .	DB	22 37 48.3	14 31 0.9	f	12-inch	160	B	G. disappearance. Haze.
23	*η Tauri* . . .	RD	23 43 4.5	15 36 6.4	g	12-inch	160	B	G. reappearance. Haze.
23	*B.D.* +23°.536	DB	22 34 32.5	14 27 45.6	g	26-inch	250	H	N. pr. *η Tauri*.
23	*B.D.* +23°.536	RD	23 41 39.6	15 34 41.8	g	26-inch	183	H	
23	28 *Tauri* . . .	DB	23 30 59.4	15 24 3.3	g	26-inch	250	H	
23	28 *Tauri* . .	RD	0 31 4.3	16 23 58.4	f	26-inch	183	H	Haze. Daylight.
23	28 *Tauri* . . .	DB	23 30 59.2	15 24 3.1	g	12-inch	160	B	Gradual. Haze.
23	28 *Tauri* . .	RD	0 31 4.1	16 23 58.2	f	12-inch	160	B	Haze. Dawn.
23	27 *Tauri* .	DB	23 36 20.9	15 29 23.9	g	26-inch	250	H	
23	27 *Tauri* . . .	DB	23 36 21.0	15 29 24.0	g	12-inch	160	B	G. disappearance. Haze.
23	27 *Tauri* . .	RD	0 15 6.2	16 8 2.9	f	12-inch	160	B	Haze. Dawn.
Aug. 7	*b Scorpii* . . .	DD	16 10 50.0	7 6 7.4	f	26-inch	183	H	
7	*b Scorpii* . . .	RB	17 31 3.5	8 26 7.8	p	26-inch	250	H	Late 0^{s}.3.
7	*b Scorpii* . .	DD	16 10 50.0	7 6 7.4	p	12-inch	235	B	Twilight.
7	*b Scorpii* . .	RB	17 31 3.6	8 26 7.9	p	12-inch	160	B	
10	189 *B. Sagittarii*	DD	17 54 27.5	8 37 40.2	f	26-inch	250	H	Haze and clouds.
12	29 *Capricarni* . .	DD	20 11 21.2	10 46 19.6	f	26-inch	250	H	
12	29 *Capricorni* . .	RB	21 26 48.9	12 1 35.0	f	26-inch	250	H	
12	29 *Capricorni* . .	DD	20 11 21.2	10 46 19.6	f	12-inch	160	B	G. disap. Thin clouds.
24	*Saturn's* Ring first contact	DB	1 15 50.1	15 2 47.8	vp	26-inch	183	H	Too early by 2^{s}.
24	*Saturn's* Ring last contact	DB	1 16 56.4	15 3 53.9	vp	26-inch	183	H	Too early by 2^{s}.
24	*Saturn's* Ring first contact	RD	2 17 32.9	16 4 20.5	p	26-inch	183	H	
24	*Saturn's* Ring last contact	RD	2 18 52.4	16 5 39.8	p	26-inch	183	H	Early 1^{s}.
24	*Saturn's* Ring first contact	DB	1 15 56.0	15 2 53.7	p	12-inch	160	B	
24	*Saturn's* Ring last contact	DB	1 17 3.4	15 4 0.9	p	12-inch	160	B	
24	*Saturn's* Ring first contact	RD	2 17 32.1	16 4 19.7	p	12-inch	235	B	
24	*Saturn's* Ring last contact	RD	2 18 52.0	16 5 39.4	p	12-inch	235	B	
24	*Saturn* (first contact)	DB	1 16 15.4	15 3 13.0	p	12-inch	160	B	
24	*Saturn* (last contact)	DB	1 16 44.2	15 3 41.7	p	12-inch	160	B	
24	*Saturn* (first contact)	RD	2 17 56.6	16 4 44.1	p	12-inch	235	B	
24	*Saturn* (last contact)	RD	2 18 31.6	16 5 19.0	p	12-inch	235	B	
Sept. 18	139 *Tauri*	DB	4 35 53.5	16 44 0.7	p	26-inch	250	H	Uncertain. Limb boiling.

Date		Object	Phen	Wash. Sid. T	Wash. M. T.	See'g	Instrum't	Pow'r	Obs.	Remarks
1916				h m s	h m s					
Sept.	18	139 *Tauri*	RD	5 4 26.1	17 12 28.6	p	26-inch	250	H	Late $0^{s}.2$.
	18	139 *Tauri*	DB	1 35 18.5	16 43 55.7	p	12-inch	160	ECB	Very poor observation.
	18	139 *Tauri*	RD	5 4 26.1	17 12 28.6	p	12-inch	160	ECB	Late $0^{s}.2$.
Oct.	5	*o Capricorni*	DD	23 9 37.5	10 11 47.7	p	12-inch	160	ECB	Late $0^{s}.1$.
	7	*ρ Aquarii*	DD	23 0 37.9	9 54 57.8	g	26-inch	250	H	Late $0^{s}.1$.
	7	*ρ Aquarii*	RB	0 6 7.2	11 0 16.3	g	26-inch	250	H	
	7	*ρ Aquarii*	DD	23 0 38.2	9 54 58.1	p	12-inch	160	ECB	Late $0^{s}.2$.
	7	*ρ Aquarii*	RB	0 6 14.6	11 0 23.7	p	12-inch	160	ECB	Late several seconds.
	12	*μ Arietis*	DB	23 47 40.1	10 22 12.7	f	12-inch	160	H	
	13	17 *Tauri*	DB	4 58 7.7	15 27 53.6	f	26-inch	250	H	
	13	17 *Tauri*	RD	5 48 32.2	16 18 9.8	g	26-inch	183	H	
	13	17 *Tauri*	DB	4 58 7.7	15 27 53.6	p	12-inch	160	ECB	Uncertain ±$0^{s}.5$.
	13	17 *Tauri*	RD	5 48 32.4	16 18 10.0	p	12-inch	160	ECB	Late $0^{s}.1$.
	13	23 *Tauri*	DB	5 30 22.6	16 0 3.2	g	26-inch	250	H	
	13	23 *Tauri*	RD	6 52 17.4	17 21 44.5	g	26-inch	183	H	
	13	23 *Tauri*	DB	5 30 21.1	16 0 1.7	p	12-inch	160	ECB	Early $0^{s}.2$.
	13	23 *Tauri*	RD	6 52 17.5	17 21 44.7	p	12-inch	160	ECB	Late $0^{s}.2$.
	13	*η Tauri*	DB	6 20 48.8	16 50 21.1	f	26-inch	250	H	
	13	*η Tauri*	RD	7 28 2.7	17 57 24.0	f	26-inch	183	H	Late $0^{s}.2$.
	13	*η Tauri*	DB	6 20 49.0	16 50 21.3	p	12-inch	160	ECB	Uncertain. Late $0^{s}.2$.
	13	*η Tauri*	RD	7 28 2.3	17 57 23.6	p	12-inch	160	ECB	Late $0^{s}.3$.
	13	27 *Tauri*	DB	7 13 31.7	17 42 55.3	f	26-inch	250	H	Twilight.
	13	27 *Tauri*	RD	8 23 20.4	18 52 32.6	p	12-inch	115	ECB	Uncertain. Late $0^{s}.3$. day-light
	13	28 *Tauri*	DB	7 19 35.9	17 48 58.5	p	26-inch	250	H	Twilight.
	13	28 *Tauri*	DB	7 19 34.7	17 48 57.3	p	12-inch	160	ECB	Uncertain. Early $0^{s}.5$.
	13	28 *Tauri*	RD	8 20 37.0	18 49 49.7	p	12-inch	115	ECB	Uncertain. Late $0^{s}.4$. day-light.
	19	*o² Cancri*	DB	4 11 33.5	14 17 51.6	p	12-inch	160	ECB	Uncertain. Late $0^{s}.5$.
	19	*o² Cancri*	RD	5 19 14.9	15 25 21.9	p	12-inch	115	ECB	Late $0^{s}.2$.
	19	*o′ Cancri*	DB	4 18 54.3	14 25 11.2	p	12-inch	160	ECB	Uncertain. Late $0^{s}.5$.
	19	*o′ Cancri*	RD	5 14 10.1	15 20 17.9	p	12-inch	115	ECB	Late $0^{s}.2$.
Nov.	8	26 *Arietis*	DB?	7 33 40.1	16 20 46.8	p	26-inch	250	H	Early $0^{s}.2$.
	8	26 *Arietis*	RB	7 54 4.3	16 41 7.6	p	26-inch	250	H	Late 2^{s}.
	10	36 *Tauri*	DB	21 49 39.1	6 30 29.7	p	26-inch	250	H	Moon's limb v. unsteady.
	10	36 *Tauri*	RD	22 47 6.3	7 27 47.4	p	26-inch	250	H	Late.
	10	36 *Tauri*	DB	21 49 38.6	6 30 29.2	p	12-inch	160	B	Gradual.
	10	36 *Tauri*	RD	22 47 4.6	7 27 45.7	p	12-inch	160	B	
Dec.	2	16 *Piscium*	DD	4 16 39.2	11 29 56.4	f	26-inch	183	H	
	2	16 *Piscium*	DD	4 16 39.3	11 29 56.5	p	12-inch	115	ECB	Late $0^{s}.2$.
	5	47 *B. Arietis*	DD	1 49 58.9	11 51 22.8	f	26-inch	250	H	Considerably earlier than ephemeris time.
	5	47 *B. Arietis*	RB	6 5 19.4	13 6 31.0	p	12-inch	160	B	Poor observation. Windy
	6	*ε Arietis*	DD	3 55 36.8	10 53 13.7	p	26-inch	250	H	Double star. Earlier than ephemeris time.
	6	*ε Arietis*	RB	4 36 14.0	11 33 44.2	p	26-inch	250	H	
	6	*ε Arietis*	DD	3 55 37.1	10 53 14.0	p	12-inch	160	ECB	Late $0^{s}.15$.
	7	27 *Tauri*	DD?	1 14 39.8	8 8 47.2	f	26-inch	250	H	Clouds.
	7	27 *Tauri*	RB	1 54 15.2	8 48 16.1	f	26-inch	250	H	Late $0^{s}.5$.
	26	*π Capricorni*	DD	23 54 37.5	5 34 15.7	p	26-inch	183	H	
	26	*π Capricorni*	DD	23 54 37.3	5 34 15.5	f	12-inch	235	B	Good disappearance.
1917										
Jan.	6	5 *Geminorum*	RB	0 13 0.1	5 9 20.2	p	26-inch	250	H	Late 2^{s}.

Date	Object	Phen.	Wash. Sid. T.	Wash. M. T.	See'g	Instrum't	Pow'r	Obs.	Remarks
1917			h m s	h m s					
Jan. 7	δ *Geminorum*	DE	9 46 1.8	14 36 52.2	f	26-inch	250	H	Good disap. During eclipse
7	δ *Geminorum*	RE	11 0 39.2	15 51 17.3	f	26-inch	250	H	During eclipse.
7	δ *Geminorum*	RE	11 0 39.0	15 51 17.1	f	12-inch	160	B	During eclipse.
8	85 *Geminorum*	RD	1 40 54.3	6 29 8.2	p	26-inch	250	H	Late $0^s.25$.
8	85 *Geminorum*	RD	1 40 55.2	6 29 9.1	p	12-inch	160	ECB	Uncertain. Late 1^s ±.
8	217 *B. Geminorum* . .	DB	3 23 52.9	8 11 49.9	p	26-inch	250	B	Gradual. Haze.
9	54 *Cancri*	DB	5 36 39.3	10 20 18.7	p	26-inch	250	B	Gradual. Haze.
11	155 *B. Leonis*	RD	8 43 10.0	13 18 26.9	f	26-inch	183	H	
11	155 *B. Leonis*	RD	8 43 10.2	13 18 27.1	p	12-inch	115	ECB	Late $0^s.15$.
26	19 *Piscium*	DD	2 46 8.8	6 23 25.6	p	26-inch	183	H	
26	19 *Piscium*	RB	3 51 51.3	7 28 57.3	p	26-inch	250	H	Late $0^s.5$.
26	19 *Piscium*	DD	2 46 8.9	6 23 25.7	p	12-inch	115	ECB	Late $0^s.1$.
26	19 *Piscium*	RB	3 51 52.2	7 28 58.2	p	12-inch	160	ECB	Late $0^s.8$ ±. Uncertain.
30	66 *Arietis*	DD	9 17 31.8	12 38 0.9	f	12-inch	235	B	
30	66 *Arietis*	RB	10 3 29.2	13 23 50.7	p	12-inch	160	B	Uncertain. Clouds.
Feb. 3	44 *Geminorum* . .	DD	10 58 0.1	14 2 29.0	p	26-inch	250	H	
3	44 *Geminorum*	RB	12 3 55.3	15 8 13.4	p	26-inch	250	H	Late $0^s.25$.
3	44 *Geminorum*	DD	10 58 0.2	14 2 29.1	p	12-inch	160	ECB	Late $0^s.2$.
3	44 *Geminorum*	RB	12 3 57.7	15 8 15.8	p	12-inch	160	ECB	Late 2^s ±. Uncertain.
Mar. 6	83 *B. Leonis*	DD	9 16 49.5	10 19 41.8	g	26-inch	250	H	
6	83 *B. Leonis*	RB	10 17 20.7	11 20 3.1	g	26-inch	250	H	Late $0^s.5$.
6	83 *B. Leonis*	DD	9 16 49.6	10 19 41.9	p	12-inch	235	B	
6	89 *B. Leonis*	DD	11 7 38.0	12 10 12.1	g	26-inch	250	H	
6	89 *B. Leonis*	RB	12 26 33.0	13 28 54.2	g	26-inch	250	H	Late $0^s.5$.
6	89 *B. Leonis*	DD	11 7 38.0	12 10 12.1	f	12-inch	235	B	
6	89 *B. Leonis*	RB	12 26 31.4	13 28 52.6	f	12-inch	160	B	Uncertain.
6	π *Leonis*	DD	12 40 24.8	13 42 43.7	g	26-inch	250	H	
6	π *Leonis*	RB	13 53 45.4	14 55 52.3	g	26-inch	250	H	
6	π *Leonis*	DD	12 40 24.6	13 42 43.5	f	12-inch	235	B	
6	π *Leonis*	RB	13 53 44.3	14 55 51.2	f	12-inch	160	B	Late.
31	10 *H. Caneri*	DD	7 52 11.6	7 17 0.1	p	26-inch	183	B	Haze.
Apr. 3	155 *B. Leonis*	DD	8 29 6.1	7 42 0.9	f	26-inch	250	H	
3	155 *B. Leonis*	DD	8 29 6.2	7 42 1.0	g	12-inch	160	ECB	Late $0^s.2$.
3	155 *B. Leonis*	RB	9 53 38.0	9 6 19.0	g	12-inch	160	ECB	Late $0^s.3$.
10	σ *Scorpii*	DB	16 9 8.2	14 53 16.3	p	26-inch	250	H	Haze.
10	σ *Scorpii*	RD	17 30 26.5	16 14 21.2	p	26-inch	183	H	
10	σ *Scorpii*	DB	16 9 7.3	14 53 15.4	vp	12-inch	160	ECB	Uncertain ± 1^s.
10	σ *Scorpii*	RD	17 30 26.9	16 14 21.6	f	12-inch	160	ECB	Gradual. Late $0^s.2$.
10	Star pr. σ *Scorpii* . .	RD	17 29 32.6	16 13 27.5	p	26-inch	183	H	
14	σ *Capricorni*	RD	16 29 23.0	14 57 44.1	p	26-inch	183	B	Haze.
14	σ *Capricorni*	RD	16 29 23.3	14 57 44.4	p	12-inch	115	ECB	Late $0^s.25$.
May 10	191 *B. Sagittarii* . . .	DB	18 46 1.1	15 31 46.1	p	26-inch	250	B	Gradual. Uncertain.
10	191 *B. Sagittarii* . . .	DB	18 46 2.3	15 31 47.3	f	12-inch	160	ECB	Uncertain ± $1^s.5$.
June 25	p^3 *Leonis*	DD	14 18 33.1	8 4 10.4	f	26-inch	183	H	Dark limb visible. Twilight
25	p^3 *Leonis*	RB	15 30 56.3	9 16 21.4	vp	26-inch	250	H	Late 1^s.
25	p^3 *Leonis*	DD	14 18 33.5	8 4 10.5	f	12-inch	115	ECB	Late $0^s.1$.
25	p^3 *Leonis*	RB	15 30 56.6	9 16 21.7	p	12-inch	160	ECB	Late about 2^s.
July 4	222 *B. Sagittarii* . .	DB	19 37 34.0	12 46 55.5	f	26-inch	250	H	Limb boiling. Probably trifle early.
4	222 *B. Sagittarii* . . .	RD	20 52 30.9	14 1 40.1	f	26-inch	250	H	Near bright limb. Late 1^s.

Date	Object	Phen.	Wash. Sid. T.	Wash. M. T.	See'g	Instrum't	Pow'r	Obs.	Remarks
1917			h m s	h m s					
Aug. 5	16 *Piscium*	RD	18 27 25.2	9 31 9.1	f	12-inch	115	B	
5	19 *Piscium*	DB	23 15 32.8	14 18 29.5	f	26-inch	250	H	Gradual.
5	19 *Piscium*	RD	0 31 13.3	15 33 57.6	g	26-inch	183	H	
5	19 *Piscium*	DB	23 15 31.6	14 18 28.3	g	12-inch	160	B	
5	19 *Piscium*	RD	0 31 13.3	15 33 57.6	g	12-inch	115	B	
7	101 *Piscium*	DB	23 35 9.9	14 30 11.5	f	26-inch	250	H	
10	62 *Tauri*	DB	0 29 16.0	15 12 21.0	f	26-inch	250	H	
10	62 *Tauri*	DB	9 29 18.3	15 12 23.3	p	12-inch	160	ECB	Late $0^{s}.3$. Uncertain $\pm 1^{s}.5$
10	62 *Tauri*	RD	1 9 37.5	15 52 35.9	f	12-inch	115	ECB	Late $0^{s}.2$.
10	*B.D.* +23°.683	RD	1 7 38.2	15 50 36.9	f	26-inch	183	H	Star pr. 62 *Tauri*.
28	222 *B. Sagittarii*	DD	20 16 43.5	9 49 43.5	f	26-inch	495	B	
28	222 *B. Sagittarii*	RB	21 7 49.5	10 40 41.2	p	26-inch	250	B	
28	222 *B. Sagittarii*	DD	20 16 43.7	9 49 43.7	f	12-inch	115	ECB	Late $0^{s}.2$.
Sept. 6	161 *B. Tauri* (brighter comp.)	DB	22 41 38.8	11 38 51.9	p	26-inch	250	B	Gradual. Haze.
6	161 *B. Tauri* (brighter comp.)	RD	23 43 32.6	12 40 35.6	p	26-inch	183	B	Haze.
6	161 *B. Tauri* (fainter comp)	RD	23 43 41.8	12 40 44.7	p	26-inch	183	B	Haze.
6	161 *B. Tauri*	RD	23 43 32.7	12 40 35.7	p	12-inch	115	ECB	Late $0^{s}.3$.
26	95 *B. Capricorni*	DD	0 18 47.2	11 57 6.2	f	26-inch	183	H	
26	95 *B. Capricorni*	DD	0 18 47.2	11 57 6.3	p	12-inch	160	ECB	Late $0^{s}.2$.
26	95 *B. Capricorni*	RB	1 17 30.6	12 55 40.1	vp	12-inch	160	ECB	Uncertain. Late about 4^{s}.
29	19 *Piscium*	DD	0 16 27.9	11 42 59.6	g	26-inch	250	H	
29	19 *Piscium*	RB	1 28 14.7	12 54 34.7	g	26-inch	250	H	Very foggy. Late 1^{s}.
29	19 *Piscium*	DD	0 16 28.0	11 42 59.7	f	12-inch	169	B	
29	19 *Piscium*	RB	1 28 12.6	12 54 32.6	f	12-inch	160	B	Haze.
30	136 *B. Piscium*	DB	23 21 20.8	10 44 5.6	f	26-inch	178	H	
30	136 *B. Piscium*	RD	0 33 22.3	11 55 55.3	p	26-inch	178	H	Late.
30	136 *B. Piscium*	DB	23 31 21.8	10 44 6.6	p	12-inch	160	B	Gradual.
30	136 *B. Piscium*	RD	0 33 15.4	11 55 48.4	p	12-inch	160	B	
Oct. 4	95 *Tauri*	DB	3 29 53.3	14 36 13.8	f	26-inch	250	H	Clouds. Uncertain.
4	95 *Tauri*	RD	4 56 42.7	16 2 48.9	g	26-inch	183	H	Late $9^{s}.5$. Thin clouds.
4	95 *Tauri*	DB	3 29 52.8	14 36 13.3	f	12-inch	160	B	Gradual. Thin clouds.
4	95 *Tauri*	RD	4 56 42.8	16 2 49.0	f	12-inch	115	B	Thin clouds. Probably a little late.
7	61 *Geminorum*	DB	2 26 28.5	13 21 11.7	f	26-inch	178	H	
7	61 *Geminorum*	RD	3 16 28.7	14 11 3.7	f	26-inch	183	H	
7	61 *Geminorum*	DB	2 26 30.7	13 21 13.9	p	12-inch	160	B	Haze. Gradual.
7	61 *Geminorum*	RD	3 16 28.7	14 11 3.7	f	12-inch	115	B	

NOTES

DD signifies disappearance at dark limb of *Moon;* DB, disappearance at bright limb; DE, disappearance at eclipsed limb; RD, reappearance at dark limb; RB, reappearance at bright limb; RE, reappearance at eclipsed limb. Under "Seeing," g = good; f = fair; p = poor; v p = very poor.

Observers: H = A. Hall; B = H. E. Burton; E C B = E. C. Bower.

All observations were recorded on chronograph. Occulting bars were attached to eyepieces of powers 250, 178, and 160.

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Editor, Benjamin Boss, Albany, N. Y.; Associate Editors: E. E. Barnard, Ernest W. Brown, F. R. Moulton and R. S. Woodward
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OBSERVATIONS OF *EROS*,

MADE WITH THE 20-INCH EQUATORIAL OF THE CHAMBERLIN OBSERVATORY, UNIVERSITY PARK, DENVER, COL.,

By HERBERT A. HOWE.

The observations in 1912 were made, with the Bruce micrometer, by the usual method of transits over fixed wires, and also by a method not known to have been hitherto used in such work with an equatorial. A hand-driven traveling wire was added to the micrometer, and the objects were kept bisected by this, as they drifted through the field. For a single evening the plan adopted was as follows:

The planet and its comparison star drifted through, and their times of transit over ten fixed wires were noted. They came through again, and twenty records for each object were made with the traveling wire; again they were made to pass through the field, and twenty more similar records were made. Finally ten more records were made over fixed wires. Thus the average hour angle at which the fixed wire observations were made was close to the mean hour angle for the traveling wire observations. Then another comparison star was taken, and the same program of observing was carried out. There were thus normally four sets of observations on each night; the one printed first is for fixed wires; the one printed second is for the traveling wire; the third one printed is for fixed wires, and the fourth one is for the traveling wire. These two kinds of observations are thus available for a study of relative personal equation. If we assume that the traveling wire observations are practically free from personal equation, the absolute personal equation for the older method of observing may be found.

The experience with *Eros* in 1912 led the observer to think that a motor-driven wire, controlled by hand, was preferable. A motor of 1/30 H.P. was therefore installed for driving the wire, and the 1914 observations of *Eros* were made with it. The order of observing used in 1912 was still kept; so the observations printed first and third on a given date were with fixed wires, the second and fourth being with the movable wire. However, on Sept. 16, 1914, each of the two sets was made with fixed wires, as also on Dec. 21 and Dec. 24. The single set of Jan. 8, 1915, was made with fixed wires.

The reductions of the observations were made in duplicate and sometimes in triplicate by students in the University of Denver.

The chief computers were LILLIAN ANDERSEN, HAROLD R. BAKER, GLADYS BOGGESS, FRANCES HOLE, RACHEL ISBELL, DORA LOUTHAN, EDITH LUTTON, WALDO H. LYONS, MARIE MALCOM, ESTHER MOLES, OSCAR B. PARROTT, and LUCILE WINN.

Date Denver M. T.	*	No. of Comp.	$\Delta\alpha$	$\Delta\delta$	App. α	App. δ	log. $p\Delta$		Red. to App. Pl.	
							α	δ	α	δ
					Eros					
1912 d h m s			m s	′ ″	h m s	° ′ ″			s	″
July 8 12 11 39	133	20 , 8	−4 52.38	− 5 21.1	20 54 34.46	−20 17 26.6	9.290*n*	0.869	+2.89	+ 5.8
8 12 12 38	133	40 , 8	−4 52.71	− 5 21.1	20 54 34.13	−20 17 26.6	9.286*n*	0.869	+2.89	+ 5.8
8 13 3 29	134	20 , 8	+3 50.31	− 8 17.7	20 54 31.19	−20 17 25.0	8.598*n*	0.878	+2.91	+ 5.1
8 13 4 40	134	40 , 8	+3 49.99	− 8 17.9	20 54 30.87	−20 17 25.2	8.946*n*	0.878	+2.91	+ 5.1
10 11 24 11	135	20 , 8	−4 27.57	+ 2 50.1	20 51 28.57	−20 12 46.2	9.419*n*	0.858	+2.94	+ 5.8
10 11 24 44	135	40 , 8	−4 27.72	+ 2 50.3	20 51 28.42	−20 12 46.0	9.418*n*	0.858	+2.94	+ 5.8
10 11 51 43	136	10 , 4	−3 37.51	+ 6 36.2	20 51 26.63	−20 12 40.2	9.326*n*	0.866	+2.94	+ 5.7
10 12 10 21	136	20 , 4	−3 38.59	+ 6 36.9	20 51 25.55	−20 12 39.5	9.246*n*	0.871	+2.94	+ 5.7
12 11 38 19	137	20 , 8	−3 55.09	− 8 32.7	20 48 8.92	−20 7 55.5	9.335*n*	0.865	+2.99	+ 5.6

Date Denver M. T.	*	No. of Comp.	Δα	Δδ	App. α	App. δ	log pΔ		Red. to App. Pl.	
							α	δ	α	δ
1912 d h m s			m s	′ ″	h m s	° ′ ″			s	″
July 12 11 38 0	137	40 , 8	−3 55.09	− 8 32.6	20 48 8.92	−20 7 55.4	9.336*n*	0.865	+2.99	+ 5.6
12 12 14 50	134	20 , 8	−2 35.42	+ 1 16.4	20 48 6.55	−20 7 50.5	9.161*n*	0.874	+3.00	+ 5.5
12 12 15 29	134	40 , 8	−2 34.54	+ 1 17.3	20 48 6.43	−20 7 49.6	9.157*n*	0.874	+3.00	+ 5.5
15 10 45 20	138	20 , 8	−2 2.12	+ 2 25.3	20 42 59.44	−20 0 29.9	9.448*n*	0.854	+3.07	+ 5.2
15 10 48 29	138	40 , 8	−2 2.68	+ 2 27.2	20 42 58.88	−20 0 28.0	9.440*n*	0.855	+3.07	+ 5.2
15 11 14 51	139	20 , 8	−2 33.54	+ 0 31.5	20 42 57.09	−20 0 27.7	9.358*n*	0.863	+3.07	+ 5.2
15 11 15 13	139	40 , 8	−2 33.66	+ 0 31.3	20 42 56.97	−20 0 27.9	9.357*n*	0.863	+3.07	+ 5.2
20 10 21 58	140	19 , 8	−4 11.88	+ 0 58.0	20 33 46.38	−19 47 6.9	9.433*n*	0.855	+3.16	+ 4.6
20 10 24 1	140	40 , 8	−4 12.25	+ 1 0.8	20 33 46.01	−19 47 4.1	9.427*n*	0.855	+3.16	+ 4.6
20 11 0 37	141	20 , 8	−4 44.20	+ 0 53.5	20 33 43.19	−19 46 58.8	9.302*n*	0.866	+3.16	+ 4.7
20 11 3 0	141	40 , 8	−4 44.44	+ 0 53.8	20 33 42.95	−19 46 58.5	9.292*n*	0.867	+3.16	+ 4.7
Aug. 1 10 4 38	142	20 , 8	+3 1.13	− 8 35.7	20 10 47.01	−19 7 16.9	9.236*n*	0.867	+3.29	+ 2.3
1 10 5 19	142	40 , 8	+3 0.90	− 8 35.8	20 10 46.78	−19 7 17.0	9.233*n*	0.867	+3.29	+ 2.3
1 10 33 38	143	20 , 8	+2 54.77	+13 54.5	20 10 44.01	−19 7 21.2	9.058*n*	0.872	+3.30	+ 2.3
1 10 34 49	143	40 , 8	+2 54.43	+13 55.3	20 10 43.67	−19 7 20.4	9.049*n*	0.872	+3.30	+ 2.3
8 10 15 18	144	20 , 8	−4 51.27	− 9 2.4	19 58 19.00	−18 39 16.8	8.844*n*	0.872	+3.30	+ 2.2
8 10 15 50	144	40 , 8	−4 51.40	− 9 3.0	19 58 18.87	−18 39 17.4	8.837*n*	0.872	+3.30	+ 2.2
8 10 48 3	145	20 , 8	+2 35.70	− 7 24.0	19 58 16.63	−18 39 9.3	7.203*n*	0.873	+3.29	+ 1.4
8 10 47 44	145	40 , 8	+2 35.63	− 7 24.1	19 58 16.56	−18 39 9.4	7.353*n*	0.873	+3.29	+ 1.4
9 9 54 47	146	20 , 8	+3 8.91	+ 1 59.0	19 56 41.57	−18 35 7.5	9.002*n*	0.870	+3.29	+ 1.4
9 9 55 0	146	40 , 8	+3 8.71	+ 2 0.6	19 56 41.37	−18 35 5.9	9.000*n*	0.870	+3.29	+ 1.4
9 10 15 31	147	20 , 8	−1 31.84	− 5 47.4	19 56 40.21	−18 35 5.4	8.762*n*	0.872	+3.30	+ 1.8
9 10 16 23	147	40 , 8	−1 32.03	− 5 47.6	19 56 40.02	−18 35 5.6	8.748*n*	0.872	+3.30	+ 1.8
10 9 39 53	148	10 , 4	−2 41.90	− 5 53.7	19 55 6.47	−18 30 53.5	9.077*n*	0.868	+3.30	+ 1.8
10 9 47 26	148	40 , 8	−2 42.69	− 5 52.1	19 55 5.68	−18 30 51.9	9.018*n*	0.869	+3.30	+ 1.8
10 10 8 3	149	20 , 8	+2 2.16	+ 0 34.2	19 55 4.01	−18 30 48.3	8.791*n*	0.871	+3.29	+ 1.3
10 10 7 53	149	40 , 8	+2 2.03	+ 0 35.0	19 55 3.88	−18 30 47.5	8.793*n*	0.871	+3.29	+ 1.3
13 9 42 2	150	20 , 8	−3 30.59	− 5 58.3	19 50 31.26	−18 17 46.5	8.912*n*	0.870	+3.29	+ 1.3
13 9 41 58	150	40 , 8	−3 30.71	− 5 58.3	19 50 31.14	−18 17 46.5	8.912*n*	0.870	+3.29	+ 1.3
13 10 1 3	151	10 , 4	+2 7.64	− 9 32.8	19 50 29.95	−18 17 41.8	8.493*n*	0.871	+3.27	+ 0.9
13 10 6 25	151	20 , 4	+2 7.15	− 9 31.6	19 50 29.46	−18 17 40.6	8.493*n*	0.871	+3.27	+ 0.9
17 9 16 20	152	20 , 8	−6 34.11	+ 9 19.4	19 45 5.56	−17 59 55.4	8.958*n*	0.868	+3.28	+ 1.1
17 9 16 27	152	40 , 8	−6 34.06	+ 9 19.2	19 45 5.61	−17 59 55.6	8.957*n*	0.868	+3.28	+ 1.1
17 9 51 32	153	19 , 8	+2 13.25	+14 13.1	19 45 3.60	−17 59 45.5	8.257*n*	0.870	+3.25	+ 0.3
17 9 51 35	153	40 , 8	+2 13.10	+14 12.5	19 45 3.45	−17 59 46.1	8.255*n*	0.870	+3.25	+ 0.3
31 8 31 23	154	20 , 8	−1 34.46	+10 2.4	19 32 37.39	−16 56 37.3	8.645*n*	0.864	+3.11	− 0.4
31 8 31 49	154	40 , 8	−1 34.66	+10 3.0	19 32 37.19	−16 56 36.7	8.637*n*	0.864	+3.11	− 0.4
31 8 50 1	155	20 , 8	−1 35.50	+10 0.4	19 32 36.99	−16 56 32.8	7.759*n*	0.865	+3.11	− 0.4
31 8 49 24	155	40 , 8	−1 35.67	+10 1.4	19 32 36.82	−16 56 31.8	7.844*n*	0.865	+3.11	− 0.4
Sept. 2 9 37 39	156	20 , 8	−1 0.21	− 8 27.7	19 31 40.42	−16 47 26.9	9.041	0.861	+3.07	− 0.3
2 9 37 32	156	40 , 8	−1 0.25	− 8 27.4	19 31 40.38	−16 47 26.6	9.040	0.861	+3.07	− 0.3
2 10 6 11	157	20 , 8	−5 4.41	+ 4 10.9	19 31 39.91	−16 47 21.8	9.221	0.856	+3.10	− 0.0
2 10 6 8	157	40 , 8	−5 4.44	+ 4 11.7	19 31 39.88	−16 47 21.0	9.221	0.856	+3.10	− 0.0
5 10 11 55	158	20 , 8	−1 24.01	+ 4 38.9	19 30 40.29	−16 34 2.0	9.304	0.852	+3.04	− 0.3
5 10 11 49	158	40 , 8	−1 24.22	+ 4 38.0	19 30 40.08	−16 34 2.9	9.303	0.852	+3.04	− 0.3
5 10 31 40	159	20 , 8	−1 33.14	− 0 4.6	19 30 39.88	−16 34 1.3	9.375	0.847	+3.04	− 0.2
5 10 31 42	159	40 , 8	−1 33.28	− 0 4.4	19 30 39.74	−16 34 1.1	9.376	0.847	+3.04	− 0.2
6 9 39 57	160	20 , 8	+1 28.11	− 1 53.7	19 30 26.55	−16 29 47.3	9.170	0.857	+3.01	− 0.5
6 9 40 17	160	40 , 8	+1 27.89	− 1 53.5	19 30 26.33	−16 29 47.1	9.172	0.857	+3.01	− 0.5
6 9 57 14	161	20 , 8	+1 11.10	+ 0 27.6	19 30 26.21	−16 29 39.3	9.259	0.854	+3.02	− 0.5

Date Denver M.T.		*	No. of Comp.	Δα	Δδ	App. α	App. δ	log pΔ		Red. to App. Pl.	
								α	δ	α	δ
1912	d h m s			m s	′ ″	h m s	° ′ ″			s	″
Sept.	6 9 57 0	161	40 , 8	+1 11.06	+ 0 27.5	19 30 26.17	−16 29 39.4	9.257	0.854	+3.02	− 0.5
Oct.	12 8 2 10	162	20 , 8	−3 47.90	−13 56.1	19 50 14.13	−13 48 18.8	9.282	0.839	+2.57	+ 1.4
	12 8 0 23	162	40 , 8	−3 48.17	−13 57.8	19 50 13.86	−13 48 20.5	9.275	0.839	+2.57	+ 1.4
	12 8 26 27	163	10 , 4	−3 48.65	−15 56.9	19 50 15.34	−11 48 10.7	9.372	0.834	+2.57	+ 1.5
Nov.	1 7 44 42	164	20 , 8	−1 33.38	− 0 0.8	20 17 56.25	−11 53 18.5	9.397	0.822	+2.38	+ 3.4
	1 7 44 36	164	40 , 8	−1 33.42	− 0 0.9	20 17 56.21	−11 53 18.6	9.397	0.823	+2.38	+ 3.4
	1 8 4 54	165	20 , 8	−1 55.13	− 6 17.8	20 17 47.68	−11 53 14.6	9.452	0.818	+2.38	+ 3.4
	1 8 4 11	165	40 , 8	−1 55.23	− 6 18.2	20 17 47.58	−11 53 15.0	9.450	0.818	+2.38	+ 3.4
	5 8 15 25	166	20 , 8	+0 37.18	− 3 27.6	20 24 27.05	−11 26 13.1	9.496	0.811	+2.34	+ 3.6
1914 Sept.	16 10 3 55	167	20 , 6	+1 10.14	− 8 45.8	23 47 3.42	+24 14 23.9	9.401*n*	0.431	+3.71	+23.5
	16 10 15 52	168	20 , 6	−2 22.02	+ 1 48.7	23 47 2.32	+24 14 27.0	9.360*n*	0.419	+3.71	+23.6
	19 9 30 29	169	20 , 6	+3 31.29	+ 8 52.7	23 41 29.35	+24 27 18.0	9.449*n*	0.443	+3.71	+23.9
	19 9 30 27	169	40 , 8	+3 31.16	+ 8 52.8	23 41 29.22	+24 27 18.1	9.450*n*	0.443	+3.71	+23.9
	19 10 2 13	170	20 , 6	−3 27.74	− 3 38.3	23 41 26.79	+24 27 21.7	9.346*n*	0.411	+3.72	+24.0
	19 10 2 25	170	40 , 8	−3 27.74	− 3 38.7	23 41 26.79	+24 27 21.3	9.346*n*	0.411	+3.72	+24.0
	23 9 44 10	171	20 , 6	+2 16.81	−10 19.5	23 33 42.73	+24 36 20.9	9.326*n*	0.403	+3.71	+24.6
	23 9 43 58	171	40 , 8	+2 16.84	−10 20.2	23 33 42.76	+24 36 20.2	9.327*n*	0.403	+3.71	+24.6
	23 10 11 20	172	20 , 6	+1 23.72	− 4 18.2	23 33 40.41	+24 36 20.6	9.195*n*	0.381	+3.71	+24.6
	23 10 12 42	172	40 , 6	+1 23.50	− 4 18.4	23 33 40.19	+24 36 20.4	9.187*n*	0.380	+3.71	+24.6
	24 9 34 2	173	15 , 6	+0 45.92	−11 56.1	23 31 45.58	+24 37 5.2	9.343*n*	0.406	+3.71	+24.8
	24 9 39 36	173	40 , 8	+0 45.44	−11 55.0	23 31 45.10	+24 37 6.3	9.321*n*	0.404	+3.71	+24.8
	24 10 2 46	174	20 , 6	−2 43.41	−10 20.0	23 31 43.21	+24 37 7.4	9.211*n*	0.382	+3.72	+24.8
	24 10 3 14	174	40 , 8	−2 43.54	−10 21.4	23 31 43.08	+24 37 6.0	9.208*n*	0.382	+3.72	+24.8
Oct.	9 7 56 40	175	20 , 6	−2 44.21	− 8 14.1	23 4 1.72	+23 42 9.4	9.379*n*	0.437	+3.60	+26.7
	9 8 0 7	175	40 , 8	−2 44.32	− 8 14.2	23 4 1.61	+23 42 9.3	9.367*n*	0.434	+3.60	+26.7
	9 8 25 51	176	10 , 3	−4 52.66	− 0 11.8	23 3 59.87	+23 42 2.6	9.260*n*	0.412	+3.61	+26.8
	9 8 37 1	176	40 , 8	−4 53.45	− 0 15.2	23 3 59.08	+23 41 59.2	9.203*n*	0.405	+3.61	+26.8
	26 10 1 21	177	20 , 6	+2 6.55	+ 3 14.7	22 45 13.52	+21 4 53.9	9.291	0.475	+3.35	+27.3
	26 10 1 31	177	40 , 8	+2 6.41	+ 3 45.4	22 45 13.38	+21 4 54.6	9.291	0.475	+3.35	+27.3
	26 10 22 59	178	20 , 6	−1 26.44	+11 8.8	22 45 13.69	+21 4 53.6	9.373	0.489	+3.37	+27.4
	26 10 23 33	178	40 , 8	−1 26.73	+11 8.4	22 45 13.40	+21 4 53.2	9.375	0.490	+3.37	+27.4
	27 10 10 41	178	20 , 6	−2 18.04	− 0 38.8	22 44 22.08	+20 53 6.1	9.346	0.488	+3.36	+27.5
	27 10 11 3	178	40 , 8	−2 18.15	− 0 40.4	22 44 21.97	+20 53 4.5	9.348	0.488	+3.36	+27.5
	27 10 35 4	179	20 , 6	−2 59.37	+ 2 38.1	22 44 21.49	+20 52 55.1	9.426	0.506	+3.37	+27.5
	27 10 35 20	179	40 , 8	−2 59.38	+ 2 38.6	22 44 21.47	+20 52 55.6	9.427	0.506	+3.37	+27.5
	29 10 30 21	180	20 , 6	+2 3.43	− 2 34.9	22 43 31.38	+20 33 1.1	9.436	0.515	+3.31	+27.2
	29 10 34 5	180	40 , 8	+2 3.32	− 2 37.4	22 43 31.27	+20 32 58.6	9.446	0.518	+3.31	+27.2
	29 10 54 27	181	20 , 6	−2 17.87	+ 1 28.0	22 43 30.60	+20 32 52.7	9.496	0.534	+3.34	+27.4
	29 10 55 1	181	40 , 8	−2 17.82	+ 1 27.2	22 43 30.65	+20 32 51.9	9.497	0.535	+3.34	+27.4
	30 10 31 49	182	20 , 6	−1 33.25	+ 3 13.6	22 43 12.51	+20 23 15.3	9.451	0.522	+3.32	+27.3
	30 10 32 9	182	40 , 8	−1 33.36	+ 3 13.2	22 43 12.40	+20 23 14.9	9.452	0.522	+3.32	+27.3
	30 10 53 18	183	20 , 6	−3 12.64	− 2 25.9	22 43 11.95	+20 23 2.6	9.502	0.540	+3.34	+27.4
	30 10 53 26	183	40 , 8	−3 12.55	− 2 26.9	22 43 12.04	+20 23 1.6	9.503	0.540	+3.34	+27.4
Nov.	3 10 14 35	184	20 , 6	+1 57.26	− 8 6.7	22 42 36.86	+19 45 15.9	9.447	0.531	+3.26	+27.2
	3 10 17 36	184	40 , 8	+1 57.20	− 8 6.3	22 42 36.80	+19 45 16.3	9.455	0.533	+3.26	+27.2
	3 10 34 57	185	20 , 6	−2 4.84	+ 1 5.2	22 42 36.72	+19 45 7.6	9.496	0.547	+3.29	+27.3
	3 10 35 27	185	40 , 8	−2 4.95	+ 1 4.6	22 42 36.61	+19 45 7.0	9.497	0.548	+3.29	+27.3
	5 9 43 4	186	15 , 6	−0 45.61	− 8 53.1	22 42 42.48	+19 27 20.1	9.375	0.520	+3.26	+27.3
	5 9 46 52	186	40 , 8	−0 45.57	− 8 52.2	22 42 42.52	+19 27 21.0	9.388	0.522	+3.26	+27.3
	5 10 7 15	187	20 , 6	−1 30.72	+ 6 27.0	22 42 42.42	+19 27 12.5	9.447	0.536	+3.27	+27.3

Date Denver M.T.	*	No. of Comp.	Δα	Δδ	App. α	App. δ	log pΔ		Red. to App. Pl.	
							α	δ	α	δ
1914 d h m s			m s	′ ″	h m s	° ′ ″			s	″
Nov. 5 10 7 47	187	40 , 8	−1 30.86	+ 6 26.7	22 42 42.28	+19 27 12.2	9.449	0.536	+3.27	+27.3
6 9 8 24	188	20 , 6	−2 44.66	+ 1 4.5	22 42 50.55	+19 18 44.8	9.253	0.504	+3.27	+27.4
6 9 9 7	188	40 , 8	−2 44.61	+ 1 4.4	22 42 50.60	+19 18 44.7	9.256	0.505	+3.27	+27.4
6 9 30 21	189	20 , 6	−2 51.58	+ 0 10.4	22 42 50.75	+19 18 39.6	9.344	0.517	+3.27	+27.4
6 9 31 1	189	40 , 8	−2 51.57	+ 0 10.2	22 42 50.76	+19 18 39.4	9.346	0.517	+3.27	+27.4
7 9 21 27	190	20 , 6	+2 9.36	− 3 44.3	22 42 2.90	+19 10 5.6	9.324	0.516	+3.22	+27.2
7 9 22 10	190	40 , 8	+2 9.43	− 3 41.4	22 43 2.97	+19 10 5.5	9.327	0.516	+3.22	+27.2
7 9 42 40	191	20 , 6	+1 59.76	− 1 54.9	22 43 3.24	+19 9 56.5	9.398	0.529	+3.23	+27.2
7 9 43 2	191	40 , 8	+1 59.67	− 1 56.8	22 43 3.15	+19 9 54.6	9.399	0.529	+3.23	+27.2
9 9 6 40	192	20 , 6	+2 18.18	− 1 37.6	22 43 38.62	+18 53 33.0	9.293	0.517	+3.21	+27.2
9 9 6 52	192	0 , 8	. .	− 1 37.1	. . . .	+18 53 33.5	9.294	0.517	. . . . .	+27.2
9 9 9 47	192	20 , 0	+2 18.08	. . .	22 43 38.42	. . . .	9.306	0.518	+3.21	. . . . .
9 9 31 9	193	20 , 6	+2 11.70	+ 4 36.8	22 43 38.69	+18 53 41.7	9.383	0.531	+3.21	+27.2
9 9 30 59	193	20 , 0	+2 11.76	. . . .	22 43 38.75	. . . .	9.391	0.532	+3.21	. . . .
9 9 33 29	.	0 , 8	. . . . .	+ 4 36.2	. . . . .	+18 53 41.1	9.383	0.531	. . . . .	+27.2
10 8 57 32	194	20 , 6	+0 35.52	− 6 49.1	22 44 1.81	+18 45 39.0	9.268	0.516	+3.21	+27.3
10 8 59 20	194	40 , 8	+0 35.39	− 6 48.7	22 44 1.68	+18 45 39.4	9.276	0.517	+3.21	+27.3
10 9 25 2	195	20 , 6	+2 12.22	− 2 46.4	22 44 2.06	+18 45 30.2	9.374	0.531	+3.20	+27.2
10 9 26 11	195	40 , 8	+2 12.02	− 2 45.9	22 44 1.86	+18 45 30.7	9.378	0.532	+3.20	+27.2
11 8 46 1	196	20 , 6	+1 46.92	+ 3 30.1	22 44 28.74	+18 38 9.4	9.230	0.515	+3.20	+27.2
11 8 46 59	196	40 , 8	+1 46.74	+ 3 29.3	22 44 28.56	+18 38 8.6	9.235	0.515	+3.20	+27.2
11 9 5 26	197	20 , 6	−2 0.88	− 3 42.3	22 44 28.73	+18 37 53.7	9.316	0.524	+3.22	+27.4
11 9 5 55	197	40 , 8	−2 0.90	− 3 42.8	22 44 28.71	+18 37 53.2	9.318	0.524	+3.22	+27.4
13 8 39 14	198	20 , 6	+0 49.76	− 2 3.7	22 45 32.83	+18 23 16.4	9.229	0.519	+3.19	+27.2
13 8 39 22	198	40 , 8	+0 49.65	− 2 4.4	22 45 32.72	+18 23 15.7	9.230	0.519	+3.19	+27.2
13 9 7 49	199	19 , 6	+4 9.20	− 0 54.0	22 45 33.38	+18 23 7.5	9.250	0.533	+3.16	+27.0
13 9 7 46	199	40 , 8	+4 9.18	− 0 55.3	22 45 33.36	+18 23 6.2	9.250	0.533	+3.16	+27.0
16 9 14 32	200	20 , 6	+2 50.22	− 2 14.6	22 47 36.63	+18 2 46.7	9.403	0.548	+3.16	+27.1
16 9 14 23	200	38 , 8	+2 50.33	− 2 15.2	22 47 36.74	+18 2 46.1	9.403	0.548	+3.16	+27.1
16 9 36 36	201	20 , 6	+2 8.34	+ 0 9.8	22 47 37.42	+18 2 42.2	9.463	0.562	+3.17	+27.1
16 9 35 43	201	39 , 8	+2 8.13	+ 0 10.5	22 47 37.21	+18 2 42.8	9.461	0.562	+3.17	+27.1
19 8 46 39	202	20 , 6	+1 25.72	+ 0 5.5	22 50 8.94	+17 44 58.5	9.340	0.543	+3.16	+27.3
19 8 49 9	202	40 , 8	+1 25.86	+ 0 5.1	22 50 9.08	+17 44 58.1	9.349	0.544	+3.16	+27.3
19 9 6 27	203	20 , 6	−1 13.94	+ 0 11.5	22 50 9.60	+17 44 52.9	9.406	0.554	+3.18	+27.4
19 9 6 26	203	40 , 8	−1 13.98	+ 0 12.1	22 50 9.56	+17 44 53.5	9.406	0.554	+3.18	+27.4
21 8 45 4	204	20 , 6	−1 33.78	+ 0 29.9	22 52 6.95	+17 34 22.9	9.355	0.548	+3.18	+27.6
21 8 46 53	204	40 , 8	−1 33.66	+ 0 30.0	22 52 7.07	+17 34 23.0	9.362	0.549	+3.18	+27.6
21 9 43 17	205	20 , 6	+5 27.36	+ 0 57.0	22 51 59.14	+17 34 9.1	9.511	0.584	+3.12	+27.2
21 9 46 54	205	40 , 8	+5 27.52	+ 0 57.5	22 51 59.30	+17 34 9.6	9.518	0.586	+3.12	+27.2
24 7 13 44	206	20 , 6	+5 15.30	+ 0 8.4	22 55 22.69	+17 20 51.9	8.808	0.523	+3.11	+27.2
24 7 14 8	206	40 , 8	+5 15.27	+ 0 7.1	22 55 22.66	+17 20 50.6	8.813	0.523	+3.11	+27.2
24 7 44 11	207	20 , 6	+4 4.06	− 0 0.3	22 55 24.11	+17 20 45.3	9.100	0.530	+3.12	+27.2
24 7 43 43	207	40 , 8	+4 3.99	− 0 0.9	22 55 24.04	+17 20 44.7	9.097	0.530	+3.12	+27.2
25 8 32 21	208	20 , 6	+4 47.28	− 1 18.2	22 56 38.59	+17 16 36.0	9.349	0.552	+3.11	+27.2
25 8 32 50	208	40 , 8	+4 47.24	− 1 17.4	22 56 38.55	+17 16 36.8	9.351	0.552	+3.11	+27.2
25 8 53 47	209	20 , 6	−1 17.34	+ 3 3.9	22 56 39.98	+17 16 30.9	9.418	0.563	+3.16	+27.5
25 8 54 9	209	40 , 8	−1 17.39	+ 3 4.3	22 56 39.93	+17 16 31.3	9.419	0.564	+3.16	+27.5
26 7 53 53	210	20 , 6	+4 41.06	− 0 43.5	22 57 52.26	+17 12 50.1	9.192	0.537	+3.11	+27.2
26 7 54 25	210	38 , 8	+4 41.10	− 0 44.1	22 57 52.30	+17 12 49.5	9.195	0.537	+3.11	+27.2
26 8 20 25	211	20 , 6	+1 5.72	− 4 55.6	22 57 56.60	+17 12 45.5	9.314	0.548	+3.14	+27.4

Date Denver M.T.	*	No. of Comp.	Δα	Δδ	App. α	App. δ	log pΔ		Red. to App. Pl.	
							α	δ	α	δ
1914 d h m s			m s	′ ″	h m s	° ′ ″			s	″
Nov. 26 8 21 1	211	40 , 8	+1 5.79	− 4 56.0	22 57 56.67	+17 12 45.1	9.317	0.548	+3.14	+27.4
Dec. 1 8 50 33	212	20 , 6	−0 56.55	− 7 34.0	23 4 53.51	+16 57 45.9	9.450	0.575	+3.16	+27.6
1 8 50 49	212	38 , 8	−0 56.50	− 7 32.7	23 4 53.56	+16 57 47.2	9.451	0.575	+3.16	+27.6
1 9 11 43	213	20 , 6	−1 34.64	−10 21.8	23 4 54.60	+16 57 48.4	9.499	0.588	+3.16	+27.6
1 9 12 4	213	40 , 8	−1 34.65	−10 22.8	23 4 54.59	+16 57 47.4	9.550	0.588	+3.16	+27.6
2 8 50 53	214	20 , 6	+5 30.32	+ 3 24.6	23 6 25.03	+16 55 40.1	9.457	0.577	+3.11	+27.2
2 8 51 2	214	40 , 8	+5 30.21	+ 3 24.9	23 6 24.92	+16 55 40.4	9.457	0.577	+3.11	+27.2
2 9 17 13	215	20 , 6	+2 49.31	+ 0 56.2	23 6 26.67	+16 55 36.8	9.515	0.594	+3.13	+27.4
2 9 17 27	215	40 , 8	+2 49.30	+ 0 56.4	23 6 26.66	+16 55 37.0	9.516	0.594	+3.13	+27.4
5 6 14 12	216	20 , 6	−2 17.24	+ 6 33.7	23 11 4.31	+16 50 50.4	7.252*n*	0.529	+3.18	+27.8
5 6 15 15	216	40 , 8	−2 17.20	+ 6 32.2	23 11 4.35	+16 50 48.9	6.536	0.529	+3.18	+27.8
5 6 39 26	217	20 , 6	−2 44.26	+ 5 19.4	23 11 6.02	+16 50 47.2	8.701	0.531	+3.18	+27.8
5 6 39 30	217	40 , 8	−2 44.36	+ 5 20.5	23 11 5.92	+16 50 48.3	8.702	0.531	+3.18	+27.8
14 6 22 27	218	15 , 6	−0 29.46	− 7 30.7	23 27 38.31	+16 48 44.5	8.733	0.532	+3.19	+28.0
14 6 28 17	218	40 , 8	−0 29.00	− 7 30.7	23 27 38.77	+16 48 44.5	8.820	0.533	+3.19	+28.0
14 7 5 26	219	20 , 6	+6 32.80	+ 2 1.6	23 27 42.05	+16 48 48.5	9.148	0.541	+3.13	+27.6
14 7 6 13	219	39 , 8	+6 32.73	+ 2 1.0	23 27 41.98	+16 48 47.9	9.153	0.542	+3.13	+27.6
21 7 8 14	220	20 , 6	+2 56.97	− 2 39.2	23 42 37.89	+16 59 54.8	9.233	0.544	+3.20	+28.3
21 7 26 53	221	20 , 6	−2 51.21	+ 7 55.6	23 42 39.91	+16 59 54.3	9.315	0.552	+3.25	+28.5
24 9 7 17	222	20 , 6	+3 47.84	− 2 42.1	23 49 43.34	+17 7 51.6	9.573	0.615	+3.21	+28.2
24 9 20 11	223	20 , 6	+3 33.69	− 0 33.8	23 49 44.56	+17 7 52.9	9.591	0.624	+3.22	+28.2
30 7 37 31	224	20 , 6	+2 51.04	+ 5 40.5	0 4 13.33	+17 27 52.7	9.400	0.557	+3.28	+28.5
30 7 38 28	224	40 , 8	+2 51.20	+ 5 40.7	0 4 13.49	+17 27 52.9	9.403	0.558	+3.28	+28.5
30 7 59 7	225	20 , 6	+2 52.94	+ 5 50.2	0 4 15.58	+17 27 55.0	9.460	0.570	+3.28	+28.5
30 7 59 23	225	40 , 8	+2 52.91	+ 5 51.4	0 4 15.55	+17 27 56.2	9.460	0.570	+3.28	+28.5
31 6 3 38	226	20 , 6	+2 19.70	+ 4 0.7	0 6 36.62	+17 31 29.9	8.864	0.520	+3.29	+28.6
31 6 4 13	226	40 , 8	+2 19.76	+ 4 0.5	0 6 36.68	+17 31 29.7	8.871	0.520	+3.29	+28.6
1915 31 6 18 55	227	10 , 3	−2 48.07	+ 4 38.4	0 6 38.42	+17 31 31.5	9.018	0.524	+3.33	+28.7
Jan. 4 7 42 51	228	20 , 6	−0 31.44	+ 2 10.6	0 17 15.55	+17 48 35.9	9.435	0.559	+0.25	+ 8.8
4 7 43 36	228	40 , 8	−0 31.35	+ 2 12.3	0 17 15.64	+17 48 37.6	9.437	0.559	+0.25	+ 8.8
4 8 21 51	229	18 , 6	+0 54.42	−12 1.8	0 17 19.89	+17 48 41.2	9.525	0.585	+0.24	+ 8.9
4 8 23 46	229	40 , 8	+0 54.45	−12 1.0	0 17 19.92	+17 48 42.0	9.528	0.587	+0.24	+ 8.9
6 8 4 56	230	20 , 6	+1 21.30	− 0 25.4	0 22 42.65	+17 57 47.6	9.495	0.573	+0.25	+ 8.8
6 8 5 56	230	38 , 8	+1 21.45	− 0 25.8	0 22 42.80	+17 57 47.2	9.498	0.574	+0.25	+ 8.8
6 8 27 4	231	20 , 6	−2 28.10	− 3 30.3	0 22 44.97	+17 57 46.6	9.539	0.589	+0.27	+ 9.0
6 8 26 24	231	40 , 8	−2 28.26	− 3 30.4	0 22 44.81	+17 57 46.5	9.538	0.589	+0.27	+ 9.0
7 6 26 41	232	20 , 6	+3 30.04	− 4 11.4	0 25 16.20	+18 2 10.9	9.140	0.519	+0.24	+ 8.8
7 6 27 4	232	38 , 8	+3 30.13	− 4 11.6	0 25 16.29	+18 2 10.7	9.142	0.519	+0.24	+ 8.8
7 6 48 30	233	20 , 6	−1 22.00	+ 9 54.2	0 25 18.44	+18 2 12.7	9.257	0.528	+0.27	+ 8.9
7 6 49 3	233	38 , 8	−1 21.86	+ 9 54.0	0 25 18.58	+18 2 12.5	9.250	0.528	+0.27	+ 8.9
8 6 12 5	234	10 , 3	−0 32.76	+11 8.8	0 28 0.75	+18 6 55.2	9.046	0.513	+0.27	+ 8.8
12 7 44 22	235	20 , 6	−3 31.50	+ 0 50.7	0 39 33.85	+18 27 13.8	9.465	0.557	+0.32	+ 9.2
12 7 44 52	235	40 , 8	−3 31.52	+ 0 51.0	0 39 33.83	+18 27 14.1	9.466	0.557	+0.32	+ 9.2
12 8 21 15	236	20 , 6	+6 13.66	+ 1 14.0	0 39 38.10	+18 27 21.4	9.542	0.584	+0.19	+ 8.6
12 8 21 48	236	40 , 8	+6 13.62	+ 1 14.3	0 39 38.06	+18 27 21.7	9.543	0.584	+0.19	+ 8.6
13 6 10 12	237	20 , 6	−5 59.72	+ 1 50.9	0 42 17.61	+18 32 6.7	9.074	0.507	+0.34	+ 9.4
13 6 11 9	237	40 , 8	−5 59.91	+ 1 49.6	0 42 17.42	+18 32 5.4	9.081	0.507	+0.34	+ 9.4
14 7 48 5	238	20 , 6	−3 17.72	− 3 38.7	0 45 24.43	+18 37 45.7	9.479	0.558	+0.33	+ 9.4
14 7 48 44	238	40 , 8	−3 17.57	− 3 40.3	0 45 24.43	+18 37 44.3	9.481	0.559	+0.33	+ 9.4
14 8 15 14	239	20 , 6	−5 18.32	+ 8 57.0	0 45 28.72	+18 37 50.3	9.535	0.579	+0.35	+ 9.4

Date Denver M.T.	*	Comp.	$\Delta\alpha$	$\Delta\delta$	App. α	App. δ	log $p\Delta$		Red. to App. Pl.	
							α	δ	α	δ
19.5 d h m s			m s	′ ″	h m s	° ′ ″			s	″
Jan. 14 8 15 31	239	40 , 8	−5 18.24	+ 8 56.1	0 45 28.80	+18 37 49.1	9.536	0.579	+0.35	+ 9.4
16 6 12 33	240	20 , 6	+1 5.64	+ 4 12.9	0 51 10.91	+18 48 2.8	9.112	0.503	+0.32	+ 9.4
16 6 14 7	240	40 , 8	+1 5.83	+ 4 13.8	0 51 11.10	+18 48 3.7	9.123	0.504	+0.32	+ 9.4
16 6 46 13	241	20 , 6	+2 10.47	+ 4 23.9	0 51 15.38	+18 48 12.5	9.291	0.518	+0.31	+ 9.4
16 6 45 45	241	39 , 8	+2 10.36	+ 4 24.7	0 51 15.27	+18 48 13.3	9.289	0.518	+0.31	+ 9.4
19 6 20 20	242	20 , 6	+0 21.24	+ 8 55.0	1 0 19.96	+19 4 21.9	9.178	0.502	+0.34	+ 9.5
19 6 20 50	242	40 , 8	+0 21.15	+ 8 55.6	1 0 19.87	+19 4 22.5	9.181	0.502	+0.34	+ 9.5
19 7 52 8	243	20 , 6	−1 26.52	+ 7 19.3	1 0 31.44	+19 4 43.7	9.500	0.558	+0.36	+ 9.6
19 7 51 57	243	40 , 8	−1 26.39	+ 7 20.6	1 0 31.57	+19 4 45.0	9.499	0.558	+0.36	+ 9.6
Feb. 2 7 3 55	244	20 , 6	−3 57.46	− 4 2.9	1 45 59.22	+20 19 46.3	9.403	0.510	+0.49	+10.3
2 7 4 25	244	40 , 8	−3 57.44	− 4 1.8	1 45 59.24	+20 19 47.4	9.405	0.510	+0.49	+10.3
2 7 33 15	245	20 , 6	+1 52.26	+13 47.6	1 46 3.67	+20 19 54.5	9.482	0.533	+0.15	+10.1
2 7 34 16	245	40 , 8	+1 52.26	+13 48.0	1 46 3.67	+20 19 54.9	9.485	0.534	+0.15	+10.1
5 6 51 54	246	20 , 6	+1 27.08	− 1 24.1	1 56 19.12	+20 34 28.1	9.370	0.498	+0.48	+10.2
5 6 52 11	246	40 , 8	+1 26.98	− 1 23.2	1 56 19.02	+20 34 29.0	9.371	0.498	+0.48	+10.2
5 7 39 38	247	20 , 6	+1 33.21	− 0 46.0	1 56 25.83	+20 34 33.1	9.501	0.536	+0.48	+10.2
5 7 39 57	247	40 , 8	+1 33.20	− 0 45.2	1 56 25.82	+20 34 33.9	9.501	0.536	+0.48	+10.2
6 6 36 1	248	15 , 6	−0 10.98	− 8 10.6	1 59 46.42	+20 39 0.3	9.313	0.486	+0.50	+10.3
6 6 31 45	248	50 , 8	−0 11.70	− 8 10.1	1 59 45.70	+20 39 0.8	9.295	0.484	+0.50	+10.3
6 8 9 52	249	20 , 6	+5 7.11	+ 0 24.3	1 59 59.64	+20 39 20.9	9.560	0.562	+0.47	+10.1
6 8 9 35	249	38 , 8	+5 6.87	+ 0 23.9	1 59 59.40	+20 39 20.5	9.559	0.562	+0.47	+10.1
8 7 48 0	250	15 , 6	+0 22.92	−10 27.5	2 6 59.54	+20 48 21.3	9.521	0.541	+0.52	+10.4
8 7 52 17	250	40 , 8	+0 23.50	−10 27.8	2 7 0.12	+20 48 21.0	9.530	0.545	+0.52	+10.4
8 8 12 26	251	20 , 6	−0 59.10	− 0 29.0	2 7 3.37	+20 48 24.7	9.566	0.563	+0.54	+10.3
8 8 12 5	251	60 , 8	−0 59.26	− 0 30.3	2 7 3.21	+20 48 23.4	9.565	0.563	+0.54	+10.3
9 7 16 2	252	20 , 6	+0 36.27	− 5 7.8	2 10 29.14	+20 52 38.1	9.448	0.512	+0.53	+10.4
9 7 30 4	252	38 , 8	+0 38.25	− 5 8.0	2 10 31.12	+20 52 37.9	9.484	0.524	+0.53	+10.4
9 7 50 1	253	20 , 6	+0 49.84	+ 9 51.7	2 10 33.91	+20 52 44.6	9.526	0.542	+0.53	+10.3
9 7 50 54	253	20 , 8	+0 49.89	+ 9 51.3	2 10 33.96	+20 52 44.2	9.528	0.543	+0.53	+10.3
10 7 36 30	254	20 , 6	−2 0.84	− 1 40.0	2 14 6.87	+20 56 54.1	9.499	0.529	+0.56	+10.5
10 7 37 1	254	40 , 8	−2 0.70	− 1 39.2	2 14 7.01	+20 56 51.9	9.500	0.530	+0.56	+10.5
10 7 58 42	255	20 , 6	−3 38.15	+ 1 14.8	2 14 10.16	+20 56 58.3	9.544	0.549	+0.57	+10.5
10 7 59 26	255	40 , 8	−3 38.07	+ 1 15.8	2 14 10.24	+20 56 59.3	9.545	0.550	+0.57	+10.5
15 8 2 56	256	20 , 6	−2 3.79	− 3 39.2	2 32 23.13	+21 15 59.8	9.555	0.550	+0.61	+10.7
15 8 3 41	256	40 , 8	−2 3.55	− 3 38.9	2 32 23.37	+21 16 0.1	9.556	0.551	+0.61	+10.7
15 8 28 4	257	20 , 6	+2 41.10	− 3 18.2	2 32 26.96	+21 16 3.6	9.594	0.575	+0.58	+10.6
15 8 28 17	257	40 , 8	+2 41.09	− 3 17.8	2 32 26.95	+21 16 4.0	9.594	0.576	+0.58	+10.6
18 7 42 16	258	20 , 6	+3 30.38	+ 9 57.4	2 43 28.82	+21 25 27.3	9.518	0.529	+0.60	+10.5
18 7 42 29	258	40 , 8	+3 30.38	+ 9 56.8	2 43 28.82	+21 25 26.7	9.518	0.529	+0.60	+10.5
18 7 56 47	259	10 , 3	+2 40.12	+ 4 42.9	2 43 31.23	+21 25 28.3	9.546	0.543	+0.61	+10.5
Mar. 13 8 0 58	260	20 , 6	−1 22.80	− 3 3.3	4 13 12.68	+21 31 16.3	9.555	0.547	+0.90	+ 9.9
13 8 2 1	260	40 , 8	−1 22.56	− 3 3.6	4 13 12.92	+21 31 16.0	9.557	0.548	+0.90	+ 9.9
13 8 39 33	261	20 , 6	+1 47.36	−10 47.9	4 13 18.96	+21 31 13.0	9.612	0.586	+0.88	+10.0
13 8 35 5	261	40 , 8	+1 47.33	−10 47.9	1 13 18.93	+21 31 13.0	9.606	0.581	+0.88	+10.0
Apr. 2 8 42 36	262	20 , 6	−1 17.18	+ 0 2.3	5 33 51.89	+19 38 12.9	9.608	0.607	+1.09	+ 7.3
2 8 43 17	262	40 , 8	−1 17.02	+ 0 2.7	5 33 52.05	+19 38 13.3	9.609	0.607	+1.09	+ 7.3
2 9 13 31	263	20 , 6	+2 44.15	+ 1 24.0	5 33 57.11	+19 38 0.3	9.639	0.635	+1.06	+ 7.4
2 9 13 55	263	40 , 8	+2 44.21	+ 1 23.6	5 33 57.17	+19 37 59.9	9.640	0.635	+1.06	+ 7.4
3 8 48 58	264	10 , 3	+0 37.94	− 6 45.2	5 37 53.07	+19 29 28.3	9.615	0.614	+1.09	+ 7.2
3 8 58 37	264	40 , 8	+0 39.40	− 6 50.4	5 37 54.53	+19 29 23.1	9.625	0.622	+1.09	+ 7.2

Mean Places of Comparison Stars for the Beginning of the Year

*	α	δ	Authority		*	α	δ	Authority	
	h m s	° ′ ″				h m s	° ′ ″		
133	20 59 23.95	−20 12 11.3	*A.G. Cordoba II*	5203	181	22 45 45.13	+20 30 57.3	*A.G. Berlin B*	8763
134	20 50 37.97	−20 09 12.4	*Cin'ti* (1885)	3506	182	22 44 42.44	+20 19 34.4	*A.G. Berlin B*	8759
135	20 55 53.20	−20 15 42.1	*Cin'ti* (1885)	3527	183	22 46 21.25	+20 25 1.1	*A.G. Berlin B*	8766
136	20 55 1.20	−20 19 22.1	*Cin'ti* (1885)	3524	184	22 40 36.34	+19 52 55.4	*A.G. Berlin A*	9301
137	20 52 1.02	−19 59 28.4	*Gould*	28711	185	22 44 38.27	+19 43 35.1	*A.G. Berlin A*	9329
138	20 44 58.49	−20 3 0.4	*Cin'ti* (1885)	3487	186	22 43 24.83	+19 35 45.9	*A.G. Berlin A*	9322
139	20 45 27.56	−20 1 4.4	*Cin'ti* (1885)	3488	187	22 44 9.87	+19 20 18.2	*A.G. Berlin A*	9326
140	20 37 55.10	−19 48 9.5	*Cin'ti* (1885)	3457	188	22 45 31.94	+19 17 12.9	*A.G. Berlin A*	9338
141	20 38 24.23	−19 47 57.0	*Cin'ti* (1885)	3460	189	22 45 39.06	+19 18 1.8	*A.G. Berlin A*	9339
142	20 7 42.59	−18 58 43.5	*Cin'ti* (1885)	3356	190	22 40 50.32	+19 13 22.7	*A.G. Berlin A*	9304
143	20 7 45.94	−19 21 18.0	*Cin'ti* (1885)	3357	191	22 41 0.25	+19 11 24.2	*A.G. Berlin A*	9305
144	20 3 6.97	−18 30 16.6	*Weiss-Arg.*	15929	192	22 41 17.13	+18 54 43.4	*A.G. Berlin A*	9308
145	19 55 37.64	−18 31 46.7	*Weiss-Arg.*	15843	193	22 41 23.78	+18 48 37.7	*A.G. Berlin A*	9310
146	19 53 29.37	−18 37 7.9	*Weiss-Arg.*	15820	194	22 43 23.08	+18 52 0.8	*A.G. Berlin A*	9321
147	19 58 8.75	−18 29 19.8	*Gould*	27455	195	22 41 46.64	+18 47 49.4	*A.G. Berlin A*	9313
148	19 57 45.07	−18 25 1.6	*Weiss-Arg.*	15866	196	22 42 38.62	+18 34 12.1	*A.G. Berlin A*	9315
149	19 52 58.56	−18 31 23.8	*Weiss-Arg.*	15809	197	22 46 26.39	+18 41 8.6	*A.G. Berlin A*	9344
150	19 53 58.56	−18 11 49.5	*Weiss-Arg.*	15826	198	22 44 39.88	+18 24 52.9	*A.G. Berlin A*	9330
151	19 48 19.04	−18 8 9.9	*Weiss-Arg.*	15755	199	22 41 21.02	+18 23 34.5	*A.G. Berlin A*	9309
152	19 51 36.39	−18 9 15.9	*Weiss-Arg.*	15791	200	22 44 43.25	+18 4 34.2	*A.G. Berlin A*	9332
153	19 42 47.10	−18 13 58.9	*Weiss-Arg.*	15690	201	22 45 25.91	+18 2 5.3	*A.G. Berlin A*	9337
154	19 34 8.74	−17 6 39.3	*A.G. Washington*	7377	202	22 48 40.06	+17 44 25.7	*A.G. Berlin A*	9353
155	19 34 9.38	−17 6 32.8	*A.G. Washington*	7378	203	22 51 20.36	+17 44 14.0	*A.G. Berlin A*	9370
156	19 32 37.56	−16 38 58.9	*A.G. Washington*	7366	204	22 53 37.55	+17 33 25.4	*A.G. Berlin A*	9387
157	19 36 41.22	−16 51 32.7	*A.G. Washington*	7404	205	22 46 38.66	+17 32 44.9	*A.G. Berlin A*	9345
158	19 32 1.26	−16 38 40.6	*A.G. Washington*	7360	206	22 50 4.28	+17 20 16.3	*A.G. Berlin A*	9361
159	19 32 9.98	−16 33 56.5	*A.G. Washington*	7361	207	22 51 16.93	+17 20 18.4	*A.G. Berlin A*	9369
160	19 28 55.43	−16 27 53.1	*A.G. Washington*	7342	208	22 51 48.20	+17 17 27.0	*A.G. Berlin A*	9373
161	19 29 12.09	−16 30 6.4	*A.G. Washington*	7346	209	22 57 54.16	+17 12 59.5	*A.G. Berlin A*	9419
162	19 53 59.46	−13 34 24.1	*A.G.Camb.(U.S.)*	7024	210	22 53 8.09	+17 13 6.4	*A.G. Berlin A*	9378
163	19 54 1.42	−13 32 15.3	*A.G.Camb.(U.S.)*	7025	211	22 56 47.74	+17 17 13.7	*A.G. Berlin A*	9406
164	20 19 27.25	−11 53 21.1	*A.G.Camb.(U.S.)*	7197	212	23 5 46.90	+17 4 52.3	*A.G. Berlin A*	9475
165	20 19 50.43	−11 47 0.2	*A.G.Camb.(U.S.)*	7200	213	23 6 26.08	+17 7 42.6	*A.G. Berlin A*	9478
166	20 23 47.53	−11 22 49.1	*A.G.Camb.(U.S.)*	7229	214	23 0 51.60	+16 51 48.3	*A.G. Berlin A*	9445
167	23 45 49.57	+24 22 46.2	*A.G. Berlin B*	9108	215	23 3 34.23	+16 54 13.2	*A.G. Berlin A*	9463
168	23 49 20.63	+24 12 14.7	*A.G. Berlin B*	9128	216	23 13 18.37	+16 43 48.9	*A.G. Berlin A*	9513
169	23 37 54.35	+24 18 1.4	*A.G. Berlin B*	9072	217	23 13 47.10	+16 45 0.0	*A.G. Berlin A*	9518
170	23 44 50.81	+24 30 36.0	*A.G. Berlin B*	9099	218	23 28 4.58	+16 55 47.2	*A.G. Berlin A*	9605
171	23 31 22.21	+24 46 15.8	*A.G. Berlin B*	9035	219	23 21 6.12	+16 46 19.3	*A.G. Berlin A*	9565
172	23 32 12.98	+24 40 14.2	*A.G. Berlin B*	9040	220	23 39 37.72	+17 2 5.7	*A.G. Berlin A*	9677
173	23 30 55.95	+24 48 36.5	*A.G. Berlin B*	9032	221	23 45 27.87	+16 51 30.2	*A.G. Berlin A*	9708
174	23 34 22.90	+24 47 2.6	*A.G. Berlin B*	9052	222	23 45 52.29	+17 10 5.5	*A.G. Berlin A*	9711
175	23 6 42.33	+23 49 56.8	*A.G. Berlin B*	8875	223	23 46 7.65	+17 7 58.5	*A.G. Berlin A*	9712
176	23 8 48.92	+23 41 47.6	*A.G. Berlin B*	8886	224	0 1 19.01	+17 21 43.7	*A.G. Berlin A*	9782
177	22 43 3.62	+21 0 41.9	*A.G. Berlin B*	8751	225	0 1 19.36	+17 21 36.3	*A.G. Berlin A*	9783
178	22 46 36.76	+20 53 17.4	*A.G. Berlin B*	8769	226	0 4 13.63	+17 27 0.6	*A.G. Berlin A*	14
179	22 47 17.48	+20 49 49.5	*A.G. Berlin B*	8771	227	0 9 23.16	+17 26 24.4	*A.G. Berlin A*	35
180	22 41 24.64	+20 35 8.8	*A.G. Berlin B*	8738	228	0 17 46.74	+17 46 16.5	*A.G. Berlin A*	75

*	α	δ	Authority		*	α	δ	Authority	
	h m s	° ′ ″				h m s	° ′ ″		
229	0 16 25.23	+18 0 34.1	*A.G. Berlin A*	72	247	1 54 52.14	+20 35 8.9	*A.G. Berlin B*	598
230	0 21 21.10	+17 58 4.2	*A.G. Berlin A*	92	248	1 59 56.90	+20 47 0.6	*A.G. Berlin B*	622
231	0 25 12.80	+18 1 7.9	*A.G. Berlin A*	118	249	1 54 52.06	+20 38 46.5	*A.G. Berlin B*	597
232	0 21 45.92	+18 6 13.5	*A.G. Berlin A*	96	250	2 6 36.10	+20 58 38.4	*A.G. Berlin B*	652
233	0 26 40.17	+17 52 9.6	*A.G. Berlin A*	130	251	2 8 1.93	+20 48 43.4	*A.G. Berlin B*	661
234	0 28 33.24	+17 55 37.6	*A.G. Berlin A*	148	252	2 9 52.34	+20 57 35.5	*A.G. Berlin B*	672
235	0 43 5.03	+18 26 13.9	*A.G. Berlin A*	211	253	2 9 43.54	+20 42 42.6	*A.G. Berlin B*	671
236	0 33 24.25	+18 25 58.8	*A.G. Berlin A*	173	254	2 16 7.15	+20 58 23.6	*A.G. Berlin B*	710
237	0 48 16.99	+18 30 6.4	*A.G. Berlin A*	231	255	2 17 47.74	+20 55 33.0	*A.G. Berlin B*	717
238	0 48 41.82	+18 41 15.2	*A.G. Berlin A*	235	256	2 34 26.31	+21 19 28.3	*A.G. Berlin B*	798
239	0 50 46.69	+18 28 43.9	*A.G. Berlin A*	250	257	2 29 45.28	+21 19 11.2	*A.G. Berlin B*	780
240	0 50 4.95	+18 43 40.5	*A.G. Berlin A*	243	258	2 39 57.84	+21 15 19.4	*A.G. Berlin B*	820
241	0 49 4.60	+18 43 39.2	*A.G. Berlin A*	239	259	2 40 50.50	+21 20 34.9	*A.G. Berlin B*	826
242	0 59 58.38	+18 55 17.4	*A.G. Berlin A*	298	260	4 14 34.58	+21 34 9.7	*A.G. Berlin B*	1391
243	1 1 57.60	+18 57 14.8	*A.G. Berlin A*	307	261	4 11 30.72	+21 41 50.9	*A.G. Berlin B*	1375
244	1 49 56.19	+20 23 38.9	*A.G. Berlin A*	543	262	5 35 7.98	+19 38 3.3	*A.G. Berlin A*	1624
245	1 44 10.96	+20 5 56.8	*A.G. Berlin A*	520	263	5 31 11.90	+19 36 28.9	*A.G. Berlin A*	1599
246	1 54 51.56	+20 35 42.0	*A.G. Berlin B*	596	264	5 37 14.04	+19 36 6.3	*A.G. Berlin A*	1652

NOTES

1912 July 10. *Eros* very faint in haze.
Aug. 8. At 10h 27m *Eros* was practically in coincidence with a star of magnitude 12. In the traveling wire observations *Eros* was poorly bisected.
13. *Eros* rather faint in haze. Very poor bisection of *Eros* with traveling wire.
Sept. 5. Poor seeing.
Oct. 12. Planet became invisible in haze.
Nov. 5. Planet quite faint.
1914 Sept. 23. Traveling wire bisections poor.
Nov. 13. Poor seeing; telescope shook in wind.
16. Seeing bad.
Dec. 24. *Moon* near; planet faint.
30. Planet quite faint in strong moonlight.
1915 Jan. 4. Work unsatisfactory, from haze.
6. *Eros* difficult in haze.
7. *Eros* of magnitude 11.
8. *Eros* dim and finally vanished in haze.
14. Telescope shaken a little by the wind.
Apr. 3. Measuring poor because of haze, which finally blotted *Eros* out.

CONTENTS.

OBSERVATIONS OF *Eros*, BY HERBERT A. HOWE.

EDITOR, BENJAMIN BOSS, ALBANY, N. Y.; ASSOCIATE EDITORS: E. E. BARNARD, ERNEST W. BROWN, F. R. MOULTON AND R. S. WOODWARD
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OBSERVATIONS OF THE SATELLITES OF *SATURN*,

By E. E. Barnard.

The following observations of the satellites of *Saturn* are a continuation of those printed in *A.J.*, Vol. XXX, p. 33. They have not been corrected for refraction.

In the observations of *Hyperion* the satellite was identified, in nearly every case, by its motion, so that no question as to identity, with the exception perhaps of March 20, will occur. On three dates the magnitude of *Hyperion* was estimated.

1916 Dec. 30, 14 magnitude.
1917 Jan. 6, 14½ magnitude.
Jan. 13, 14 magnitude.

The last column of the table of observations gives the position angle of the wires at the distance measures.

Measures of the Satellites.

1916–17	C. S. Time	P. A.	Dist.	Cps.	P.A. of Wires
		Enceladus and Mimas			
	h m s	°	″		°
Feb. 13	9 32 31	273.54	.....	5	....
	9 38 7	..	63.61	10	3.7
		Tethys and Mimas			
Feb. 10	13 39 55	62.57	....	5	...
	13 44 37	....	17.49	10	52.4
27	9 54 26	73.42	..	6	...
	9 59 17		27.41	10	163.0
May 1	8 39 12	360.25	....	5	....
	8 46 13	...	24.99	10	90.3
8	7 44 5	95.82	....	5	...
	7 49 38	.....	16.59	10	5.6
		Tethys and Enceladus			
Sept. 22	15 58 41	4.90	.....	5	...
	16 3 33	.....	9.32	8	94.7
Oct. 26	17 23 28	255.11	.....	6	....
	17 29 37	.....	22.74	10	165.2

1916–17	C. S. Time	P. A.	Dist.	Cps.	P.A. of Wires
		Tethys and Enceladus — Continued.			
	h m s	°	″		°
Oct. 31	16 12 4	39.30	.....	5	....
	16 16 55	.....	12.60	10	129.1
Dec. 16	17 5 29	321.24	..	5	..
	17 11 23	.	14.20	10	51.5
27	13 22 19	69.99	.....	5	..
	13 28 2	...	60.43	10	160.0
Jan. 6	11 32 35	292.86	.....	5	....
	11 37 9	...	42.84	10	22.8
Feb. 8	14 44 1	56.19	.....	5	..
	14 49 23	....	19.50	10	145.0
13	9 44 4	223.54	.....	5	....
	9 48 44	...	21.35	10	132.7
Mar. 20	9 16 54	21.98	.....	5	....
	9 21 48	...	16.75	10	111.9
Apr. 10	8 46 35	74.95	.....	5	....
	8 52 0		14.01	10	165.0

Tethys and Enceladus — Continued.

1916-17	C. S. Time	P. A.	Dist.	Cps.	P. A. of Wires
	h m s				°
May 8	7 54 39	71.75	.	5	. . .
	7 59 33	.	66.00	10	161.6

Dione and Mimas

1916-17	C. S. Time	P. A.	Dist.	Cps.	P. A. of Wires
Oct. 3	16 19 27	131.79		5	. .
	16 26 1	. .	11.74	8	41.7

Dione and Enceladus

1916-17	C. S. Time	P. A.	Dist.	Cps.	P. A. of Wires
Sept. 18	16 47 24	324.19	.	5	
	16 53 46	. . .	22.65	7	54.3
Dec. 9	16 0 0	1.70		5	.
	16 5 21		11.72	10	91.4
Jan. 13	14 40 35	27.32		6	. . . .
	11 47 40		26.70	10	117.6
27	15 15 58	296.53	. .	5	
	15 20 18	. . .	21.62	10	26.6
Feb. 10	13 28 53	295.20	. . .	6	.
	13 33 15	.	14.78	10	25.4

Dione and Tethys

1916-17	C. S. Time	P. A.	Dist.	Cps.	P. A. of Wires
Sept. 18	16 20 28	258.64	. . .	5	
	16 28 30		32.01	10	168.3
Oct. 21	16 50 27	285.20	. . .	5	
	16 56 36		63.10	10	15.6
26	17 14 7	62.72	.	5	. .
	17 18 43		34.39	10	152.7
31	16 1 1	42.16	.	6	.
	16 6 50		9.49	10	131.6
Nov. 2	16 59 55	181.03		5	. .
	17 5 26		29.86	10	94.5
18	15 51 45	316.38		5	
	15 56 50	.	13.25	4	16.2
Dec. 2	16 28 55	232.72		5	
	16 35 7		12.03	10	142.8
9	15 35 55	334.25		5	
	15 42 21		38.77	5	61.4

Dione and Tethys — Continued.

1916-17	C. S. Time	P. A.	Dist.	Cps.	P. A. of Wires
	h m s	°	″		°
Dec. 16	17 30 5	92.91	. . . . .	5	. . . .
	17 35 55	.	103.10	10	3.0
27	13 10 0	139.13	. .	5	. . .
	13 15 15	. .	40.78	9	49.0
Jan. 6	11 11 33	240.24	. . .	5	.
	11 45 43	. .	18.08	10	150.8
25	15 4 15	286.69	. . . . .	5	. . .
	15 8 59	. .	24.87	10	16.3
Feb. 10	12 40 35	278.39	. .	5	. . . .
	12 45 39	. . .	77.46	10	8.4
13	9 56 45	4.21		5	. . . .
	9 59 57	. .	23.46	8	93.7
17	12 45 25	80.35	. . .	5	. . .
	12 51 29	. . .	51.16	10	170.4
Mar. 20	9 26 23	320.96	. .	6	. . .
	9 30 42	. . . . .	12.78	10	50.9
27	9 41 27	253.21	. . .	5	. . . .
	9 45 15	. . . .	26.42	10	163.0
Apr. 10	8 36 27	168.87	. . . .	5	. .
	8 40 59	. . . .	37.47	10	79.0
May 1	8 51 33	243.09	.	4	. . .
	8 55 52	. .	42.45	8	152.6
8	8 4 38	60.73	. . . . .	5	. .
	8 8 41	. . .	12.16	10	150.6

Dione and Hyperion

1916-17	C. S. Time	P. A.	Dist.	Cps.	P. A. of Wires
Dec. 30	15 10 29	173.29	. . .	6	. . .
	15 46 37	. . . . .	81.01	10	83.3

Rhea and Mimas

1916-17	C. S. Time	P. A.	Dist.	Cps.	P. A. of Wires
Dec. 30	15 3 37	240.02	. . . . .	5	. . .*
	15 10 5	. . . . .	49.00	10	150.3
Mar. 20	9 2 22	308.25	. . . . .	6	
	9 10 13	. . . . .	37.43	10	38.1

**Mimas* very faint

Rhea and Enceladus

1916–17	C. S. Time	P. A.	Dist.	Cps.	P. A. of Wires
	h m s	°	″		°
Oct. 3	17 0 59	69.47	. . .	5	. .
	17 6 15		93.35	10	159.2
10	17 16 50	219.44	. .	5	. . .
	17 23 0	.	21.51	10	129.0
Nov. 18	15 26 26	286.95	.	5	
	15 32 36		60.99	8	16.8
Dec. 30	15 17 12	260.14	. .	6	
	15 22 45	. .	66.76	10	170.3
Feb. 17	13 24 35	272.30		6	. . .
	13 31 15	. . . .	44.91	10	2.4
27	8 57 12	244.65	. .	5	.
	9 1 45	. .	38.22	10	155.0
Mar. 27	9 48 49	181.17		5	.
	9 52 15	. .	35.35	8	91.0

Rhea and Tethys

1916–17	C. S. Time	P. A.	Dist.	Cps.	P. A. of Wires
Sept. 22	16 21 1	168.83	. . .	5	. . .
	16 25 15	. . .	35.80	8	78.7
Oct. 10	17 29 17	248.48	. . .	5	
	17 33 44	. . . . .	80.42	8	.
Nov. 18	15 39 28	24.57	. . . .	5	. .
	15 45 27	. . . . .	41.87	10	114.2
27	16 19 37	21.36	.	5	. .
	16 25 26	.	18.06	10	111.7
Dec. 2	16 52 26	271.05		5	. . .
	16 58 1		120.29	10	1.3
16	17 16 17	251.76	. . . .	4	. .
	17 22 30		42.94	9	161.5
30	15 28 30	262.26	. .	5	. . . .
	15 33 9		97.32	10	172.3
Jan. 6	11 24 12	76.58	. . .	5	
	11 28 19	. . . .	118.38	8	166.3
13	13 28 13	223.00	. .	5	.
	13 35 37	. . .	74.14	10	133.1

Rhea and Tethys — Continued.

1916–17	C. S. Time	P. A.	Dist.	Cps.	P. A. of Wires
	h m s	°	″		°
Jan. 27	14 58 5	101.29	. . . .	5	
	15 3 8	. . .	55.95	10	11.1
Feb. 10	12 28 45	148.65	. . .	6	
	12 34 25	. .	28.81	10	58.4
17	12 58 48	287.92	.	5	. . . .
	13 1 56	. . .	82.16	10	139.4
27	9 7 7	256.13	. . .	5	. . .
	9 11 46	. .	115.93	10	166.0
Mar. 27	9 33 52	116.58	. . . .	5	. . .
	9 37 48	. . .	22.34	10	26.5
Apr. 10	8 26 55	121.11	. .	5	. .
	8 31 38		57.77	10	31.0

Rhea and Dione

1916–17	C. S. Time	P. A.	Dist.	Cps.	P. A. of Wires
Sept. 18	16 6 11	116.76	.	5	.
	16 12 39	. . .	73.86	10	26 8
22	16 10 4	254.85	.	6	. .
	16 15 39	. . . .	16.21	8	164.7
Oct. 3	16 4 7	29.41	.	5	. .
	16 13 46	. . .	41.81	10	119.7
3	17 23 1	18.39	. .	5	. . .
	17 26 59	. . .	37.38	10	108.2
10	17 37 57	146.68	. .	5	
	17 43 6	. . .	37.50	8	57.0
21	16 37 19	78.45		5	. . . .
	16 43 45	. . .	118.28	10	168.6
26	17 4 18	66.47	. . .	5	. . .
	17 9 14	. . . .	27.58	10	156.2
31	16 22 13	274.28	.	5	. . . .
	16 27 21	. .	83.14	10	4.1
Nov. 2	16 48 50	236.08	. . . . .	5	. . . .
	16 54 30	. . .	24.22	10	145.5
27	16 30 1	287.09	. . .	5	.
	16 36 44		88.77	10	16.7

Rhea and Dione — Continued.

1916–17	C. S. Time	P. A.	Dist.	Cps.	P. A. of Wires
	h m s	°	″		°
Dec. 2	16 40 51	288.40	.....	5	....
	16 46 45	...	92.96	10	18.3
9	15 23 20	99.03	.....	5	....
	15 29 18	.....	114.02	10	8.9
27	12 47 51	85.80	....	5	....
	12 53 56	...	31.22	10	175.5
Jan. 13	13 43 23	237.59	.....	5	...
	13 51 44	....	102.21	10	147.6
25	14 54 18	18.40	...	5	.
	14 59 27	...	30.58	10	108.3
27	15 7 18	155.84	....	5	....
	15 11 53	.....	59.59	10	66.1
Feb. 8	14 33 48	301.21	....	5	...
	14 38 53	.....	41.68	10	30.5
27	8 48 22	192.10	...	5	....
	8 52 48	...	26.27	10	102.0
Mar. 20	9 35 35	281.86	....	5	....
	9 40 40	.....	41.39	10	11.9
May 8	8 12 27	38.27	....	5	....
	8 17 29	..	16.47	10	128.1

Titan and Tethys

1916–17	C. S. Time	P. A.	Dist.	Cps.	P. A. of Wires
Nov. 27	16 50 47	83.70	.....	5	....
	16 59 58	.....	139.32	11	173.7
Dec. 9	15 48 24	186.72	....	5	....
	15 54 4	...	53.17	10	96.9

Titan and Dione

1916–17	C. S. Time	P. A.	Dist.	Cps.	P. A. of Wires
Sept. 18	16 35 49	241.09	....	5	....
	16 41 47	..	117.55	10	151.3
22	16 46 42	109.68	...	5	....
	16 51 10	....	18.59	8	19.7
Oct. 21	17 2 29	213.76	.	5	...
	17 8 37		77.17	10	123.6

Titan and Dione — Continued.

1916–17	C. S. Time	P. A.	Dist.	Cps.	P. A. of Wires
	h m s	°	″		°
Dec. 16	17 43 8	21.20	.....	5	....
	17 50 1	....	87.13	10	11.0
30	15 52 20	72.57	.....	5	....
	15 54 49	.....	135.94	10	162.3
Jan. 6	12 20 48	269.46	.....	5	...
	12 26 27	....	141.14	10	179.3
13	14 24 23	100.91	.....	5	....
	14 32 0	.....	146.15	10	11.1
25	15 30 51	190.20	.....	5	....
	15 36 28	.....	69.84	10	100.3
Feb. 10	13 17 48	204.34	.....	5	....
	13 22 37	...	105.71	10	114.4
17	13 11 24	45.54	.....	5	....
	13 17 8	...	121.98	10	135.4

Titan and Rhea

1916–17	C. S. Time	P. A.	Dist.	Cps.	P. A. of Wires
Sept. 13	17 6 59	8.33	....	5	....
	17 12 4	.....	74.57	8	98.1
Oct. 3	17 12 2	76.08	.....	5	....
	17 17 25	.....	234.16	10	166.2
26	17 35 18	95.33	.....	5	....
	17 41 1	.....	174.97	10	5.2
31	16 32 50	250.93	.....	5	....
	16 38 10	.....	39.89	10	80.6
Nov. 6	16 3 11	233.16	.....	5	....
	16 8 50	.....	61.76	5	143.2
18	16 3 5	267.79	.....	5	....
	16 10 26	.....	138.08	10	177.8
Dec. 2	17 15 19	18.50	.....	5	....
	17 21 23	.....	58.71	10	108.3
27	12 59 14	117.72	.....	5	....
	13 4 17	.....	66.77	10	27.5
Jan. 27	15 24 46	116.91	.....	5	...
	15 28 47	.....	65.73	10	27.1

Titan and Rhea — Continued.

1916–17	C. S. Time	P. A.	Dist.	Cps.	P.A. of Wires
	h m s	°	″		°
Feb. 27	9 16 41	124.82	.....	5	....
	9 21 36	...	81.23	10	*35.0
Apr. 10	8 58 40	283.01	..	5	...
	9 2 58	....	201.05	9	13.0
May 8	8 21 59	51.96	.....	5	...
	8 26 21	....	68.09	10	111.6

Titan and Hyperion

1916–17	C. S. Time	P. A.	Dist.	Cps.	P.A. of Wires
Dec. 30	16 3 41	105.53	.....	5	....
	16 9 23	.....	145.24	10	15.3
Jan. 6	12 8 35	33.81	.....	5	....
	12 14 27	.....	60.78	11	123.8
13	14 7 31	24.63	.....	5	....
	14 15 39	.....	56.76	10	114.6

* *Titan* is yellow.

Titan and Hyperion — Continued.

1916–17	C. S. Time	P. A.	Dist.	Cps.	P.A. of Wires
	h m s	°	″		°
Jan. 25	15 17 8	138.41	.....	5	....
	15 23 22	...	212.37	10	138.4
Feb. 27	9 35 44	249.95	.....	5	....
	9 41 2	....	253.19	10	160.0
Mar. 20	9 51 58	308.78	.....	5	....
	9 57 13	...	73.41	10	38.9
27	9 58 2	219.97	.....	5	....
	10 1 35		104.72	6	132.0

Rhea and a Star (?)

1916–17	C. S. Time	P. A.	Dist.	Cps.	P.A. of Wires
Oct. 3	15 48 57	312.17	.....	5	....
	15 55 46	.....	73.52	8	42.2
Jan. 6	11 5 45	300.38	.....	6	....
	11 10 55	.....	34.23	8	210.3

Estimated Magnitudes of the Satellites.

1916–17	*Mimas*	*Enceladus*	*Tethys*	*Dione*	*Rhea*
Sept. 13	...	....	12.7	12	12.5
18	...	14	13	12.2	12
22	...	13½	12.7	12.7	12½
Oct. 3	...	14	...	14	12½*
10	...	14	13	13	12½
21	...	....	13	12½	12
26	...	14	13.3	13	12
31	...	13.9	12½	13	12
Nov. 2	...	14	12½	12½	12
6	...	....	....	....	12
18	...	14	12½	12½	12
27	...	....	12½	12½	12
Dec. 2	...	....	12½	12.7	12.2
9	...	14	13	12¾	12½
16	...	14	13	13	12

* Identification uncertain.

1916–17	*Mimas*	*Enceladus*	*Tethys*	*Dione*	*Rhea*
Dec. 27	...	13½	13	13	12½
30	14	14	13	12.8	12
Jan. 6	...	14	12.7	12¼	12¼
13	...	14	13	13	12
Feb. 8	...	14	13	13.2	12
10	14?	15	12½	12½	12
13	...	13.7	12.7	12.8	12
17	...	....	12½	12½	12
27	...	14½	12.8	12.7	12
Mar. 20	14	13½	12.5	12.6	12
27	15	13½	12½	12.7	12
Apr. 10	...	14	13	13	12
May 1	14	13½	12.7	12.7	12.2
8	14.5	14	13	13	12

Yerkes Observatory, Williams Bay, Wisconsin,
1917, October 24.

SUNSPOT OBSERVATIONS,

MADE AT BERWYN, PENN., WITH A 4½-INCH REFRACTOR,

BY A. W. QUIMBY.

1917	Time	New Grs.	Total Grs.	Total Spots	Fac. Grs.	Def.	1917	Time	New Grs.	Total Grs.	Total Spots	Fac. Grs.	Def.	1917	Time	New Grs.	Total Grs.	Total Spots	Fac. Grs.	Def.
July 1	6	2	8	36	4	fair	Aug. 17	5	–	8	60	3	fair	Oct. 4	9	–	2	5	2	poor
2	6		7	25	4	fair	18	5	–	8	104	3	fair	5	8	–	3	26	4	fair
3	10	–	4	12	–	poor	19	6	–	8	76	2	fair	6	7	–	3	17	3	poor
4	9	–	1	30	1	poor	20	6	–	8	70	2	fair	7	9		3	26	3	fair
5	6	3	7	62	4	fair	21	6	1	8	87	4	fair	8	8	–	3	17	2	fair
6	6	–	7	62	3	fair	22	10	1	7	64	3	fair	10	8	–	2	16	1	poor
7	6	2	9	60	3	fair	23	7	–	5	41	2	poor	11	8	2	4	17	5	fair
8	7	–	8	71	2	fair	24	7		4	20	2	poor	12	8	2	5	17	3	poor
9	8	–	7	63	2	poor	25	7	2	5	29	4	fair	13	8	–	5	17	5	fair
10	8	–	6	42	3	poor	26	7	2	7	36	3	fair	14	8	–	5	15	5	fair
12	12	–	6	80	2	fair	27	7	2	8	44	4	fair	15	8	–	3	7	4	fair
13	7	–	5	65	2	fair	28	7	1	8	37	5	fair	16	8	2	5	7	4	fair
14	6	1	6	60	2	poor	29	9	1	7	41	2	fair	17	7	–	5	24	4	fair
15	8	2	7	36	2	poor	30	12		6	20	3	fair	19	9	1	5	22	2	poor
16	7	2	9	41	4	fair	31	9	2	8	19	3	fair	20	7	–	5	24	2	fair
17	7	–	8	19	3	poor	Sept. 1	7	2	10	41	4	fair	21	8	–	5	39	3	fair
18	5	1	7	13	3	poor	2	5	–	6	29	3	fair	22	8	1	6	42	3	fair
19	7	2	5	7	2	poor	3	9	1	7	36	3	fair	23	9	–	6	57	3	fair
20	8	–	4	9	1	poor	4	5	2	8	61	5	fair	24	11	1	7	49	2	poor
21	5	1	1	12	2	fair	5	7	–	6	56	3	fair	25	8	1	8	54	4	poor
22	7	1	5	22	3	fair	6	6	–	6	27	2	fair	26	8	–	8	36	2	poor
23	7	1	6	21	2	fair	7	7	–	6	17	1	fair	27	8	–	5	45	4	fair
24	7	–	6	50	3	fair	9	9	1	6	14	2	fair	28	8	1	4	26	4	poor
25	6	1	7	69	3	fair	10	7	1	6	15	3	fair	29	8	–	4	32	3	poor
26	6	–	7	83	2	fair	11	7	1	7	15	4	fair	30	2	–	3	20	–	poor
27	1	–	7	118	3	fair	12	7	1	8	41	4	fair	31	8	–	4	22	4	fair
28	7	–	6	90	3	fair	13	7	–	6	47	4	fair	Nov. 1	4	1	5	37	4	fair
29	7	1	6	118	3	fair	14	7	1	7	29	3	fair	2	8	–	4	24	3	poor
30	6	1	7	67	3	fair	16	7	–	4	10	2	poor	3	8	–	4	17	3	fair
31	6	1	7	80	3	fair	17	7	2	7	47	3	fair	4	8		2	22	3	fair
Aug. 1	6	0	6	51	3	fair	18	11		7	83	2	fair	5	8		2	40	4	good
2	5	2	8	32	3	fair	19	7	2	8	108	5	fair	6	8	–	2	40	3	good
3	5	1	9	27	3	fair	20	7	2	9	108	4	fair	7	8	1	3	43	2	good
4	6	–	9	34	3	fair	21	7	–	9	187	3	fair	8	8	–	3	47	3	good
5	6	2	10	45	5	fair	22	7	–	9	181	3	fair	9	3	2	5	36	3	fair
6	7	3	13	100	1	good	23	7	1	10	165	4	fair	10	8	1	6	40	4	fair
7	6	2	15	172	5	good	24	2	1	10	109	4	fair	11	9	–	6	24	3	fair
8	5	1	14	264	2	good	25	10	1	10	130	1	fair	12	8		5	20	3	fair
9	6	1	14	270	4	good	26	7		8	75	3	fair	13	8		4	15	2	poor
10	7	1	14	162	4	good	27	7	–	8	40	3	fair	14	8	1	5	18	1	poor
11	7	1	14	144	4	good	28	4	–	5	6	–	poor	15	8	2	5	22	2	fair
12	7	1	14	182	1	good	29	7		6	25	4	fair	16	8	1	6	18	1	poor
13	6	2	12	189	6	good	30	7		5	13	5	fair	17	8		6	18	1	fair
14	6	2	14	180	1	good	Oct. 1	7	–	5	16	5	fair	18	8	–	6	15	2	fair
15	9	2	14	87	2	fair	2	7		3	16	3	fair	19	8	–	6	14	2	poor
16	9	–	10	80	2	fair	3	7	–	3	15	2	fair	20	11		5	12	2	fair

SUNSPOT OBSERVATIONS (*Continued.*)

1917	Time	New Grs.	Total Grs.	Total Spots	Fac. Grs.	Def.	1917	Time	New Grs.	Total Grs.	Total Spots	Fac. Grs.	Def.	1917	Time	New Grs.	Total Grs.	Total Spots	Fac. Grs.	Def.
Nov. 21	9	1	6	22	2	fair	Dec. 4	2	1	5	15	1	poor	Dec. 18	1	-	7	18	2	poor
22	2	–	5	30	3	fair	5	8	2	7	10	3	fair	20	2	4	11	58	2	fair
23	8	–	5	17	3	poor	6	10	-	5	10	2	fair	21	8	1	12	65	3	fair
24	9	1	6	34	3	fair	7	8	1	6	10	3	fair	22	8	–	10	33	2	poor
25	4	–	4	56	2	fair	9	8	–	3	9	2	fair	23	8	–	11	48	3	fair
26	8	–	4	45	2	fair	10	8	–	2	11	1	fair	24	8		11	28	3	poor
27	8	–	4	56	2	fair	11	8	1	3	20	1	poor	26	9	-	10	51	4	fair
28	2	1	5	64	3	fair	12	8	1	4	47	1	fair	27	8	–	8	36	3	poor
29	8	-	5	64	3	fair	14	8	1	5	65	2	fair	28	8	–	7	25	4	poor
Dec. 1	8	2	7	72	3	fair	15	8	1	6	55	4	fair	29	8		8	25	3	poor
2	8		6	62	2	fair	16	3		5	20	–	poor	30	8	2	10	28	3	fair
3	8	-	6	47	2	fair	17	9	2	7	30	2	fair	31	3		5	12	-	poor

ADDITIONAL TABLE TO ACCOMPANY PAPER ON ATMOSPHERIC REFRACTION

(*A. J.* 722),

By W. T. NEILL.

Apparent Z. D.	Mean Refraction	Diff. for 10′	Correction at 40° F.	Correction at 60° F.	Correction at 29 in.	Correction at 31 in.	Apparent Z. D.
° ′	′ ″	″	″	″	″	″	° ′
85 00	9 51.9	16.4	+13.6	−13.6	−17.7	+17.8	85 00
10	10 8.3	17.2	14.1	14.1	18.1	18.2	10
20	10 25.5	18.0	14.7	14.7	18.6	18.7	20
30	10 43.5	19.0	15.3	15.3	19.1	19.2	30
40	11 2.5	20.1	15.9	15.9	19.5	19.6	40
50	11 22.6	21.2	16.5	16.4	19.9	20.0	50
86 00	11 43.8	22.3	+17.1	−17.0	−20.4	+20.5	86 00
10	12 6.1	23.6	17.9	17.7	20.9	21.1	10
20	12 29.7	25.0	18.8	18.5	21.4	21.6	20
30	12 54.7	26.5	19.8	19.4	21.9	22.1	30
40	13 21.2	28.0	20.8	20.3	22.4	22.7	40
50	13 49.2	29.7	21.9	21.3	23.0	23.3	50
87 00	14 18.9	31.7	+23.1	−22.4	−23.6	+23.9	87 00
10	14 50.6	33.8	24.4	23.5	24.2	24.5	10
20	15 24.4	36.0	25.8	24.7	24.8	25.1	20
30	16 0.4	38.5	27.4	26.1	25.4	25.7	30
40	16 38.9	41.3	29.2	27.7	26.1	26.4	40
50	17 20.2	44.4	31.2	29.5	26.8	27.1	50
88 00	18 4.6	47.9	+33.5	−31.6	−27.5	+27.9	88 00
10	18 52.5	52.1	36.3	34.1	28.2	28.9	10
20	19 44.6	57.1	39.2	36.8	29.1	30.0	20
30	20 41.7	63.1	42.5	39.8	29.9	31.0	30
40	21 44.8	69.6	46.3	43.3	30.9	32.1	40
50	22 54.4	78.8	+51.2	−48.1	−31.8	+33.3	50

Apparent Z. D.	Mean Refraction	Diff. for 10′	Correction at 40° F.	60° F.	29 in.	31 in.	Apparent Z. D
° ′	′ ″	″	″	″	″	″	° ′
89 00	24 13.2	90.1	+ 57.0	−53.6	−32.8	+34.5	89 00
10	25 43.3	103.7	63.6	59.6	34.0	36.0	10
20	27 27.0	118.9	71.8	66.7	35.1	37.5	20
30	29 25.9	121.0	81.5	74.0	36.0	39.0	30
40	31 36.9	120.7	92.0	84.4	36.4	39.5	40
50	33 37.6	54.8	101.5	92.7	35.5	39.2	50
90 00	34 32.4		+105.5	−96.4	−34.9	+38.6	90 00

ELEMENTS OF 1903 *NF*,

By A. ESTELLE GLANCY.

This is one of the few planets which are regarded as lost. Observations cover the interval from 1903, Dec. 11 to Dec. 18 only, (*A. J.*, Nos. 562, 564.) The *Berliner Jahrbuch* publishes the circular orbit computed by DINWIDDIE from his own observations on Dec. 15 and 18, (*A. J.*, No. 554), although an elliptic orbit by LEUSCHNER's method has been published by CARRIGAN and TILLYER from observations on Dec. 15, 17, 18, (*A. J.*, No. 560).

In studying the orbit of the lost planet *Æthra*, I noticed a little resemblance to the circular elements of 1903 *NF*. With a large eccentricity it seemed possible that the other elements would show a closer resemblance. Unfortunately I overlooked the elliptic orbit referred to above, which would have at once disproved an identity by reason of the large difference in ω. So an elliptic orbit was computed by LEUSCHNER's method, based on all the available observations. The discovery position is an approximate photographic place; the observations on Dec. 15 and 18 are the means of two observations. While the approximate position influences the elements, it more than doubles the available arc and therefore its use seems justified.

It can be seen by inspection that slight changes in the velocities x'_0, y'_0, z'_0, would remove the residuals in the last two observations and imprvoe those for the first observation, but in view of the approximate nature of the discovery position no differential correction has been made.

The elements are:

EPOCH 1903, DEC. 15.4907 GR. M. T.

$$\begin{aligned} M &= 83^\circ\,24'\,04'' \\ 1903.0\left\{\begin{aligned} i &= 12^\circ\,17'\,02'' \\ \Omega &= 219^\circ\,41'\,30'' \\ \omega &= 129^\circ\,33'\,09'' \end{aligned}\right. & \\ \varphi &= 6^\circ\,14'\,27'' \\ \mu &= 857''.14 \\ \log a &= 0.41131 \\ \log \rho &= 0.20709 \end{aligned}$$

CONSTANTS FOR THE EQUATOR.

$$\begin{aligned} x &= (9.99596)\sin(\ 78^\circ\,35'\,33'' + v) \\ y &= (9.98728)\sin(346^\circ\,39'\,40'' + v) \\ z &= (9.43878)\sin(\ 17^\circ\,17'\,18'' + v) \end{aligned}$$

The residuals are respectively.

	Dec. 11	Dec. 15	Dec. 17	Dec. 18
$\Delta\alpha\cos\delta$	+10″	0″	−7″	−6″
$\Delta\delta$	− 2″	0	+2	+2

These elements differ considerably from those of CARRIGAN and TILLYER.

It is unfortunate that the photographic position was not given more accurately, since the planet was followed only eight days.

Observatorio Nacional, Cordoba, June 14, 1917.

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MEASURES OF THE CLUSTER *N. G. C.* 6633,

BY FREDERICK L BROWN.

This paper is a preliminary report of the results from the measures of the cluster *N. G. C.* 6633. A complete discussion, which was presented originally as a thesis for the degree of Master of Arts at Northwestern University, will be published later. The work has been divided into two parts: first, the measurement and reduction of photographs taken with the 18$\frac{1}{2}$-inch refractor of the Dearborn Observatory in the summer of 1915, and second, the comparison of these with other measures of the cluster. This second part involves the reduction of all the positions to the common equinox of 1925.0 and to the common basis of the *Astrographic Catalog*.

The Dearborn Observatory plates measured for position contain one hundred and ninety-eight stars, one hundred and ninety-five of them appearing on all three plates used. A Gærtner measuring machine with two perpendicular screws was employed for this part of the work. The resulting rectangular coordinates were reduced to right ascensions and declinations for the equinox 1915.0 by means of TURNER's method. (See *Mon. Not.*, Vol. 54, 11-25, 1893, and *The Observatory*, Vol. 16, 373-376, 1893.) Sixteen of the cluster stars are found in the Leipzig II zone of the *A. G. Catalog*. These were reduced to 1915.0 and fourteen of them used to determine the plate constants. The other two were discarded because of their large residuals; one of them is known to have proper motion and the other may be an error in the catalog. Unfortunately the distribution of these comparison stars is not very good and their images are very large; but the resulting positions of the other stars agree well for the various plates in spite of this. The average residual from the mean position is $0^s.0037$ in R. A. and $0''.075$ in Decl.

The following table contains a list of the Dearborn Observatory plates used in this work.

PHOTOGRAPHS OF *N. G. C.* 6633 R. A. $18^h 23^m 6^s$ DECL. 6° 28′.0

Plate No.	Date	Exposure	Hour Angle	Observer	Quality
A 1378	June 8, 1915	60^m	2^h 5^mE	BROWN	Poor
		60	1 0 E	BROWN	Fair
A 1445	June 30,	30	0 26 E	FOX	Good; Trail
A 1456	July 2,	30	0 17 E	BROWN	Very good
A 1465	July 5,	30	0 40 E	FOX	Very good

Plate A 1378 was used only for the determination of magnitudes.

For the second part of the work four catalogs were available containing enough stars to warrant their reduction to a common basis.

First: Micrometric measures of seventy-one stars made by VALENTINER at Karlsruhe, in 1878.

Second: A photographic measurement of thirty-one stars by NIJLAND at Utrecht, in 1895.

Third: The *Carte du Ciel Catalog*, Toulouse zone 6°–8°, plate No. 138. This contains ninety-eight of the cluster stars for the epoch 1906.

Fourth: The remeasurement of VALENTINER's seventy-one stars by KRUSE at Heidelberg, in 1911—1912, again micrometric.

It was this last paper that led to the search for proper-motion stars, KRUSE having listed several groups that seemed to show common motion.

The positions as given in these various catalogs were all reduced to 1925.0 by means of Ristenpart's tables, except in the case of Nijland's positions, and here Newcomb's values for the precession constants were employed. The measures were still in poor agreement, due it was felt to lack of common orientation and comparison stars. To eliminate differences of this sort all the catalogs were reduced to a common basis. Fifty-seven stars found in the four catalogs of Carte du Ciel, Valentiner, Kruse, and Brown were used as comparison stars in least square solutions to determine constants which would reduce each of the last three catalogs to the system of coördinates used in the *Astrographic*. A like reduction involving twenty-seven stars was used in the case of Nijland. The method is similar to that given by Miss Young in her discussion of *h χ Persei*. (See *Contributions of the Observatory of Columbia University*, No. 24.) By using such a large number of stars it was thought that individual inaccuracies would have less effect and a better distribution could be secured. The transformation brings the catalogs into good agreement, the three photographic, as might be expected, holding more closely together than the two micrometric.

In comparing these final positions one does not find confirmation of Kruse's proper-motion classifications, except in the case of Star 174. The fact that the value of this star's proper-motion determined from this comparison is less than the values assigned to it by other sources might lead one to wonder whether the method is entirely justifiable; but that point will have to be left for the longer paper; suffice it to say here, that the majority of the apparent motions disappear leaving the positions as given by all the catalogs substantially the same. It might be of interest to remark that many of the stars to which Kruse assigns motion were measured by Valentiner on only one or two nights, so that little confidence can be placed in very small apparent motions based on these positions alone.

The table of results contains first, the author's catalog number; second, the right ascension of the star reduced to the equinox of 1925.0, and further, to the basis of the *Carte du Ciel*. Column three gives the declinations similarly reduced. The positions as given by the other catalogs have been omitted for lack of room, but will appear in the longer paper. Next follow the magnitudes which were determined by measuring the diameters of the star images on the long exposure plate, A 1378, and substituting them in the formula: —

$$\text{Magnitude} = A - B\sqrt{\text{Diameter}}$$

The constants, A and B, of the equation were determined by using Valentiner's visual estimates of the stars he measured.

The columns headed "Catalog Numbers" give the number of each star in each of the catalogs referred to in this paper, *BD* being added for help in identification. The Valentiner number given is his catalog number not his computation number.

The final column contains references to the notes following the main table.

The discussion is far too limited to give the complete data or the details of the method of reduction, but it is hoped that by using the common equinox of 1925.0 and the common basis of the *Astrographic Catalog*, the comparison of future results with these will be much simplified.

Dearborn Observatory, October, 1917.

Final Catalog

Star Number	R. A. 1925.0 Epoch 1915	Decl. 1925.0 Epoch 1915	Mag.	Catalog Numbers						Notes
	18h	6°		Valentiner	Nijland	*Carte du Ciel* Toulouse Zone 6°–8° Plate 138	Kruse	*BD* 6°	*A. G.* Leipzig II	
	m s									
1	21 34.184	34 30.30	10.5							
2	42.534	29 25.74	10.0			260				
3	43.033	24 18.74	11.5							
4	43.951	33 37.65	11.6							
5	45.483	21 51.26	11.6							
6	47.242	25 25.13	11.9							
7	49.364	18 26.73	11.9							
8	49.720	34 26.46	11.5							
9	53.262	45 1.70	10.8							
10	56.065	36 49.18	9.2			264		3744		

Star Number	R. A. 1925.0 Epoch 1915	Decl. 1925.0 Epoch 1915	Mag.	Catalog Numbers						Notes
				Valentiner	Nijland	*Carte du Ciel* Toulouse Zone 6°–8° Plate 138	Kruse	*BD* 6°	A. G. Leipzig II	
	18^h	6°								
	m s	′ ″								
11	21 58.039	10 29.96	11.3	.		265	. . .	.		. . .
12	22 0.212	40 25.02	11.7		.			.		. .
13	0.554	18 32.86	11.8	. .		. . .				.
14	1.234	45 36.68	11.3	.		268		. .		. .
15	1.314	14 58.55	10.3	.	.	267		3745		.
16	1.384	20 57.68	10.4	.	.	270		.		. . .
17	5.009	25 11.23	11.6	.	.					.
18	5.074	20 35.19	10.7	.	. .	.				.
19	6.404	44 13.50	10.4		. .	271				.
20	7.589	23 56.08	11.6		. .					*e*
21	8.060	13 35.63	10.7		.	272		3746		
22	10.791	38 21.41	10.4	.	. .	273				
23	11.230	41 35.67	11.6		.					
24	11.241	10 16.13	11.1		. .					
25	13.628	21 53.64	11.6							
26	15.640	39 3.18	10.7	. .		274				
27	17.828	32 44.32	9.5	. .		275		3747		.
28	20.828	9 42.80	11.0	. .	.			. .		
29	21.452	13 49.91	11.6	. .				.		
30	23.198	44 49.23	12.1							
31	23.321	14 6.42	11.0	.		276				.
32	23.727	9 10.31	11.6	.	. .					
33	25.970	43 17.21	11.4	. .	. .					
34	26.292	44 51.97	12.0	. .	. .	277				
35	26.320	44 50.97	12.0	. .	. .	.				. .
36	26.687	29 18.07	11.4	. .	. .	.			.	
37	29.299	19 53.33	11.4	. .	. .	. . .				
38	31.417	39 14.14	9.5	1	. .	278	1	3748		*b*
39	33.038	43 32.34	11.8	. .	. .	. .				
40	33.393	33 42.06	9.7	2	. .	280	2	3749		*b*
41	33.484	25 30.67	10.5	3		281	3	.		*b*
42	35.439	20 56.06	10.4	4	. .	283	4			*b, p*
43	35.767	19 39.69	11.3	. .	. .	284				.
44	39.533	21 23.39	11.4	. .	.	.		.		.
45	40.402	23 49.61	12.2	. .	.			. .		
46	41.447	15 0.91	12.0	. .	. .					
47	42.286	11 47.74	11.2	. .	.					
48	43.221	12 44.71	11.8	. .	. .					
49	43.713	48 44.89	8.8	6	8	286	5	3752		*b, p*
50	44.044	22 24.98	9.5	5	9	287	6	3750		*b*
51	45.434	38 11.56	10.6	7			7			
52	48.040	28 56.28	10.2	8	5	290	8			*b*
53	22 51.032	18 13.11	11.9	.	. .					

Star Number	R. A. 1925.0 Epoch 1915	Decl. 1925.0 Epoch 1915	Mag.	Catalog Numbers						Notes
	18h	6°		Valentiner	Nijland	*Carte du Ciel* Toulouse Zone 6°–8° Plate 138	Kruse	*BD* 6°	*A. G.* Leipzig II	
	m s	′ ″								
54	22 51.469	20 10.70	10.5	9	..	292	9	....	....	*b*
55	51.753	10 10.34	11.4		.			...	...	.....
56	52.258	13 24.73	11.7		..		.	....	....	.....
57	52.749	28 19.79	10.0	10	6	293	10	3755	....	*b*, *p*
58	52.885	20 27.45	10.4	11		294	11	....	....	*b*
59	52.919	24 7.24	11.1	12	.	295	12	....	....	*b*
60	53.215	24 8.43	11.1	.	.	296	..	....	....	......
61	53.233	39 28.75	11.3		.	..	..	....	...	......
62	54.109	29 43.85	9.8	13	3	297	13	....	....	*b*
63	54.333	12 45.57	11.8		..	...	..	....	....	......
64	54.620	27 44.86	10.0	15	7	298	15	....	....	*b*
65	54.650	28 53.71	8.6	14	4	299	14	3756	8499	*a*, *b*
66	57.957	21 44.34	11.7	.	.	...	..	....	....	......
67	58.828	29 46.46	8.9	16	2	300	16	3757	....	......
68	23 0.765	29 55.52	11.6	..		..	..	....	...	......
69	1.287	35 7.67	11.9	.		..	..	....	....	......
70	1.340	46 19.64	10.4	17		301	17	....	....	*b*, *p*
71	1.341	11 29.28	11.7	.		...		....	....	......
72	1.799	40 52.78	11.6	..		...		....	....	......
73	2.942	25 11.73	11.2	..	.	...	..	....	....	......
74	3.520	39 27.10	11.9	..		...	..	....	....	......
75	5.148	39 0.65	11.7	..	..	...	..	....	....	......
76	5.557	21 35.31	9.7	18	15	302	18	3758	....	......
77	6.972	33 25.14	11.5	..	.	...	..	....	....	......
78	7.076	9 43.69	11.5	..	..	...	.	....	....	......
79	7.440	18 13.38	10.0	19	12	303	19	3759	....	*b*
80	8.193	12 16.64	11.8				.	..	...	......
81	11.505	38 5.48	11.6			.			..	......
82	12.086	16 11.59	11.2			.		...	...	......
83	13.433	20 31.23	9.0	20	14	307	20	3761	8508	*a*, *b*
84	13.573	22 39.76	8.2	21	16	308	21	3762	8509	*a*, *b*, *s*
85	14.681	44 37.64	11.1			..		....	....	....
86	14.885	26 19.87	8.6	22	1	309	22	3763	8510	*a*, *b*
87	15.073	13 19.72	11.4			.		...	..	....
88	15.577	18 12.56	9.8	23	13	310	23	3764	..	*b*
89	15.658	30 45.89	11.6			..	.	...	...	.....
90	16.149	25 13.83	10.7	24		312	24	...	...	*b*
91	20.339	38 6.03	10.9			..		..	.	....
92	20.869	28 2.98	11.5			..		..		
93	21.091	22 17.57	9.3	25	17	315	25	3765	.	*b*
94	22.697	21 55.22	9.2	26	18	317	26	3766	.	*b*
95	23.339	13 43.54	9.8			318	.	3767	.	...
96	23 24.262	23 8.60	9.4	27	19	319	27	..	..	*b*

Star Number	R. A. 1925.0 Epoch 1915	Decl. 1925.0 Epoch 1915	Mag.	Catalog Numbers						Notes
	18h	6°		Valentiner	Nijland	*Carte du Ciel* Toulouse Zone 6°–8° Plate 138	Kruse	*BD* 6°	*A. G.* Leipzig II	
	m s	′ ″								
97	23 25.002	9 1.60	9.8	..	..	320	..	3768	....	......
98	25.957	29 29.02	8.5	28	25	321	28	3769	8514	*a, b*
99	28.227	40 27.15	10.8	..	..	...	..	....	....	......
100	29.293	41 4.17	10.9	..	..	323	..	....	....	......
101	30.255	29 34.07	11.5	..	..	...	..	....	....	......
102	32.152	34 57.05	11.5	..	..	...	..	....	....	......
103	32.782	47 27.96	10.8	29	..	325	29	....	....	*b, p*
104	33.249	44 3.99	11.6	..	..	...	..	....	....	......
105	33.954	22 29.86	10.6	30	..	326	30	....	....	*b*
106	34.014	31 50.11	10.1	32	..	...	31	....	....	......
107	34.075	25 48.08	9.4	31	23	328	32	3771	...	*b*
108	35.517	28 20.76	8.5	33	26	329	33	3772	8519	*a, b, c*
109	35.695	32 2.61	11.5	..	..	...	..	....	....	......
110	37.302	27 9.11	11.1	..	..	...	..	....	....	......
111	37.811	31 7.20	11.6	..	..	...	..	....	....	......
112	38.255	35 50.36	11.6	.	..	...	..	....	....	......
113	39.261	10 21.83	10.0	..	..	331	..	....	....	......
114	40.382	33 13.12	11.8	..	..	...	..	....	....	......
115	40.941	39 39.44	11.8	..	..	...	..	....	....	......
116	41.254	26 52.53	9.4	34	27	334	35	3774	....	*b*
117	41.262	36 8.08	10.0	35	..	335	36	....	....	*b*
118	42.071	26 41.91	10.5	37	..	336	37	....	....	*b*
119	44.330	39 42.18	11.4	..	..	...	..	....	....	......
120	45.130	10 45.30	11.1	..	..	338	..	....	....	......
121	46.734	11 39.78	9.4	..	..	339	..	3776	....	......
122	46.940	21 23.52	9.9	38	21	340	38	3777	....	*b*
123	47.330	31 30.94	11.7	..	..	...	..	....	....	......
124	47.376	16 3.13	10.8	..	..	...	..	....	....	......
125	49.022	34 4.70	12.0	..	..	...	..	....	....	......
126	49.909	30 1.89	11.4	..	..	341	..	....	....	......
127	50.051	32 32.78	9.2	39	32	342	39	3778	8522	*b*
128	51.561	42 3.96	10.7	..	..	...	..	....	....	......
129	52.148	30 4.13	9.3	40	34	343	40	3779	....	*b*
130	53.168	30 20.61	11.4	..	..	...	..	....	....	......
131	53.170	34 58.09	11.7	..	..	...	..	..	....	......
132	54.035	18 13.70	11.1	41	..	...	41	....	....	*p*
133	56.713	30 10.53	10.1	42	33	346	42	3780	8523	*a, b, t*
134	58.449	30 12.27	10.7	..	..	348	..	....	....	......
135	59.222	24 59.29	11.7	..	..	...	..	....	....	......
136	59.562	36 7.95	9.2	44	31	349	44	3781	....	*b*
137	59.959	29 7.02	8.7	45	29	350	45	3782	8525	*a, b*
138	24 2.044	27 32.00	11.5	..		.	..	...	...	......

Number Star	R. A. 1925.0 Epoch 1915	Decl. 1925.0 Epoch 1915	Mag.	Catalog Numbers						Notes
				Valentiner	Nijland	*Carte du Ciel* Toulouse Zone 6°–8° Plate 138	Kruse	*BD* 6°	A. G. Leipzig II	
	18h	6°								
	m s	′ ″								
139	24 3.632	40 53.69	11.5		..	...	..	....	...	......
140	4.534	38 22.24	10.6	47	..	352	46	....	...	*b, p*
141	5.139	28 16.67	10.7	46	..	353	47	...	...	*b*
142	6.263	26 34.00	10.4	48	..	354	48	...	....	*b*
143	6.490	40 26.10	9.4	49	.	355	49	3784	....	*b*
144	8.403	24 31.53	9.1	50	22	356	50	3786	...	..
145	9.891	23 15.01	11.7	..	..	...	..		....	.....
146	9.894	31 3.28	11.7	.	..	...	..	....	....	......
147	13.014	47 2.58	9.6	51	..	358	51	3785	....	*b, p*
148	13.925	31 12.05	11.8	..	..	...	..	..	....	.....
149	15.699	33 9.79	8.6	52	30	360	52	3788	8529	*a, b*
150	15.737	12 20.52	10.4	.	..	361	..	3789	...	.....
151	16.963	16 46.65	11.3	..	..	..	..	....	....	....
152	19.042	8 49.84	6.5	..	.	359	.	3790	8530	*a, m, x*
153	19.052	44 35.68	11.4	..	..	..	.	..	....	.....
154	19.522	22 58.20	10.9	53	..	362	53	...	....	*b, p*
154B	20.535	15 15.83	10.6	..	..	363	..	...	....	*d*
155	20.741	17 37.01	9.9	54	..	364	54	...	...	*b, p*
156	21.340	28 54.74	10.3	55	..	365	55	....	....	*b*
157	24.389	38 40.43	11.3	..	..	...	..	....	....	..
158	25.268	46 6.34	11.5	..	..	..	..	....	...	
159	25.331	46 7.43	11.5	..	..	..	..	....	....	.
160	27.371	39 33.39	9.6	56	..	369	56	3793	..	*b, p*
161	27.566	35 16.18	11.6	..	..	...	..	..	..	..
162	30.431	47 33.39	11.6	..	.	372	.	..	..	..
163	31.726	44 48.21	11.4	..	.	..		..	...	
164	34.678	37 39.62	11.4	..	.	..	.	..	....	
165	34.940	20 44.46	10.7	57	..	373	57	...	....	*p*
166	35.216	27 51.46	9.7	58	..	374	58	3794	..	*b*
167	35.850	31 23.62	9.7	59	..	375	59	3795	.	*b*
168	36.211	35 54.42	11.0	.	..	376	.	....	..	
169	38.883	43 6.77	8.8	60	..	377	60	3796	8539	*a, b, p*
170	39.873	22 9.07	11.5	.	..		..	....	..	...
171	41.051	28 44.94	11.5	..	..	.	.	....	...	.
172	41.403	32 31.40	10.2	61		378	61	....	..	*b*
173	43.098	18 8.55	10.2	62		379	62	....	..	*p*
174	43.272	17 8.71	8.0	64	.	380	63	3797	8544	*p, o*
175	43.623	21 56.43	8.8	63		381	64	3799	8543	*a, b, p*
176	43.813	16 39.01	11.8		.	..		..		..
177	44.113	39 35.45	8.7	65		382	65	3798	8546	*a, b, p*
178	44.742	10 42.72	10.9			383		.	.	..
179	45.554	18 28.91	11.8			.		..	..	
180	24 47.624	13 44.14	11.3					.	.	.

Star Number	R. A. 1925.0 Epoch 1915	Decl. 1925.0 Epoch 1915	Mag.	Catalog Numbers						Notes
	18h	6°		VALENTINER	NIJLAND	*Carte du Ciel* Toulouse Zone 6°–8° Plate 138	KRUSE	*BD* 6°	A. G. Leipzig II	
	m s	′ ″								
181	24 48.473	27 6.48	11.7	. .	. .	.	. .	. .	. . . .	. . .
182	48.796	19 13.99	11.8	. .		.	. .	. . .	.	. . .
183	49.432	15 44.10	11.0	. .	. .	. .	.	. . .	. .	. .
184	54.862	35 11.41	11.7	. .	.	.	. .	. . .	.	. . .
185	56.086	31 34.21	9.8	68	.	386	68	3802		*b*
186	56.163	36 27.81	11.4		. .	. .		. . .	.	. . . .
187	56.612	8 22.98	11.1	.	. .	.	. .	. . . .	. . .	. . . . .
188	59.141	42 8.09	9.9	69	. .	. .	69	. . . .	. . .	*p*
189	25 0.274	44 26.86	8.8	70	. .	388	70	3804	8550	*a, b, p*
190	4.356	45 51.95	10.9	. .	. .	390		. . . .	. . . .	. . . . . .
191	6.851	24 17.42	11.3	.	. .	. . .		. . .	. . . .	. . . . .
192	7.707	28 11.16	11.0	.	. .	.		. . .	. . . .	. . . . .
193	9.193	14 56.35	10.3		. .	. .	.	. .	. . . .	. . . . .
194	13.992	42 2.94	11.5		. .		.	. . . .	. . . .	. . . . .
195	24.651	17 18.86	11.3	.	. .	. . .		. . .	. . . .	. . . .
196	25.087	23 56.20	10.5		.	393		. . . .	. . . .	. . . .
197	25 27.633	15 42.76	9.7	. .	. .	396		3807	. . . .	. . .

NOTES

(*a*) Comparison star used in the reduction of the rectangular plate coördinates to R. A. and Decl. for 1915.0.

(*b*) Comparison star used to reduce the other four catalogs to the basis of the *Carte du Ciel for* 1925.0.

(*c*) No. 108, Center star, used as center of the Dearborn Observatory plates in the reduction of the plate coördinates.

(*d*) No. 154B, measured on only one of the plates, was overlooked on the other two.

(*e*) Nos. 20 and 190, measured on only two plates, too faint on third.

(*m*) No. 152, magnitude taken from *A. G.* not computed.

(*o*) No. 174, proper-motion star;

$\alpha = +0^s.007$	$\delta = +0''.10$	VAL.
$+0^s.0028$	$+0''.068$	KRUSE
. . . .	$+0''.044$	BROWN

(*p*) Stars classed as proper-motion stars by KRUSE.

(*s*) No. 84, Double, *βGC* 8561 1916.5 168°.6 1″.80 8.0–9.5 4*n* BROWN.

(*t*) No. 133, Double, *βGC* 8568 1916.5 108°.0 1″.16 8.5–9.5 3*n* BROWN.

(*x*) No. 152. The R. A. of this star in *Carte du Ciel* had a typographical error which has been corrected.

ON THE PROBABLE NUMBER OF NEBULÆ,

BY E. A. FATH.

In the *Astronomical Journal* for January 12, 1914, Nos. 658-659, the writer made an estimate of the probable number of nebulæ which could be photographed on Lumiere Sigma plates with one hour's exposure, using the 60-inch reflector of the Mt. Wilson Observatory. In the same article the efficiency of the 60-inch reflector was compared with the Crossley reflector of the Lick Observatory and it was suggested that possibly DR. PERRINE's estimates* of the number

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**Lick Obsy. Bulletins*, 3, 47, 1904.

of nebulæ which could be photographed with the latter instrument under the given conditions might be too high. In a letter to the writer as well as in a note* in this publication Dr. Perrine takes exception to some of my conclusions and calls attention to certain matters which he believes fully justify his former estimates. To a certain extent these may be matters of opinion but, for the most part, they could be settled by means of observations requiring only a few nights of work with the instruments mentioned above. The writer ventures the hope that those in charge may think it worth while to try to get these observations.

In the note of Dr. Perrine, mentioned above, the following statement is made: "There is a condition which has certainly tended to reduce the actual number of nebulæ on the plates taken at Mt. Wilson which Dr. Fath does not appear to have investigated. The Mt. Wilson plates cover an area of sky nearly 2½ times that of the Crossley plates. The images are considerably distorted at the edges of the Crossley plates and must be much more so at the edges of the Mt. Wilson plates, due not only to the larger area covered, but also to the larger angular aperture of the Mt. Wilson mirror, 1/5.0 as compared with the Crossley 1/5.8 . . ."

There is no question but that the images near the edges of the Mt. Wilson plates are badly distorted, but the distortion which might obliterate a star image is not so effective on a luminous area. In order to get some idea of the effect due to plate area and at the same time to make the comparison between the results obtained by the two instruments fairer, the writer went over his reduction sheets and counted the number of nebulæ in areas of different sizes on the plates. These counts were made of the nebulæ in the central portions of the plates using squares with sides, 40, 50 and 60 minutes of arc in length. The center of each square was of course at the center of the plate. The total numbers of nebulæ found within these areas and those on the entire plate are as follows:

40′ sq.	50′ sq.	60′ sq.	Entire plate
392	578	772	1031

This gives an average of 2.82, 4.16, 5.55 and 7.42 respectively per plate. Multiplying these plate averages by the number of plates of the various sizes to cover the sky we obtain the following approximate numbers as the probable number of nebulæ which can be photographed under the conditions given in the first article, namely, 262000, 247000, 229000 and 162000. This marked decrease shows clearly the effect of plate area, or rather, the increase in aberration with increase of the distance from the optical axis.

The counts also show that even when we take only the 40′ square of the 60-inch plate and compare it with the results obtained from the entire Crossley plate, which measured about 50′ × 60′, and thus make allowance for the difference in angular aperture, there is still a discrepancy between the 262000 of the writer and the half million of Dr. Perrine, which is hard to account for when it is remembered that in those areas where the Crossley plates and the 60-inch plates could be compared the same number of nebulæ could be found. The writer therefore ventures to suggest that possibly his original contention, namely, that the discrepancy can be accounted for most easily by the lack of uniformity in the distribution of the Crossley plates, may still have something in its favor.

Redfield College, Redfield, S. Dak., December 29, 1917.

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*A. J., 682, January 31, 1916.

NEW ASTRONOMICAL WORK.

New Elements of Mars and Tables for Correcting the Heliocentric Positions, by Frank E. Ross. *Astronomical Papers of the American Ephemeris and Nautical Almanac*, Vol. IX, Part II. Washington, 1917.

Third Melbourne General Catalogue of 3068 Stars, 1890, by R. L. J. Ellery. Melbourne, 1917.

Katalog von 51 Fundamentalen Polsternen, by L. Courvoisier. *Veroffentlichungen der Kong.* Sternwarte zu Berlin-Babelsberg. Band I, Heft 2. Berlin, 1915.

Uber die Rotation des Mondes, by Axel Jonsson. *Meddelanden fran Lunds Astronomiska Observatorium.* Series II, No. 15. Lund, 1917.

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LIBRA
MAR 30
ITY OF

ELEMENTS OF 1917 *W 15*,

By ERNEST CLARE BOWER and CHARLES CLAYTON WYLIE.

[Communicated by Rear Admiral T. B. Howard, U. S. Navy, Superintendent of Naval Observatory.]

An unidentified asteroid was discovered on the plate with (25) *Phocæa* taken 1917 Nov. 16, by George H. Peters, at the Naval Observatory with the 10-inch photographic telescope.

The following observations made at the Naval Observatory, Washington, with the 26-inch equatorial and the 10-inch photographic telescopes are available:

1917 G. M. T.	α (1917.0)	δ (1917.0)	$\log p_\alpha\rho$	$\log p_\delta\rho$	Observer	Instrument	Residuals O — C $\Delta\alpha$	$\Delta\delta$
	° ′ ″	° ′ ″					″	″
(1) Nov. 16.67868	42 22 44.1	+ 9 21 1.5	8.814	0.635	Peters	10-inch	− 1.9	− 0.1
(2) 17.62889	42 8 55.5	9 25 19.4	0.288*n*	0.638	Peters	10-inch	− 0.3	− 1.1
(3) 19.58215	41 41 3.6	9 34 26.4	0.550*n*	0.648	Peters	10-inch	− 2.3	+ 1.9
(4) 24.73706	40 32 11.2	9 59 38.5	0.559	0.644	Burton	26-inch	− 1.2	− 0.9
(5) 26.70707	40 7 59.4	10 9 47.3	0.433	0.633	Hall	26-inch	− 0.3	+ 0.3
(6) Dec. 1.59750	39 13 42.6	10 36 6.1	0.118*n*	0.620	Peters	10-inch	− 0.5	− 1.0
(7) 5.60292	38 35 51.4	10 58 52.1	9.719*n*	0.612	Peters	10-inch	− 1.0	+ 0.3
(8) 5.60942	38 35 50.7	10 58 55.1	9.378*n*	0.612	Burton	26-inch	+ 1.8	+ 1.1
(9) 10.58903	37 57 53.1	11 28 37.8	9.662*n*	0.605	Peters	10-inch	0.0	− 0.1
(10) 15.58882	37 30 21.2	12 0 7.2	9.279	0.597	Peters	10-inch	− 7.1	+ 4.7
(11) 29.66940	37 11 26.2	+13 36 4.5	0.696	0.623	Bower	26-inch	− 8.7	+13.5
1918	α (1918.0)	δ (1918.0)						
(12) Jan. 9.52576	37 52 59.7	+14 56 14.8	9.578	0.550	Peters	10-inch	−15.9	+22.4
(13) 9.60877	37 53 28.8	+14 56 54.7	0.587	0.583	Bower	26-inch	−14.6	+24.8

An orbit based on (1), (5) and (9) yields the above residuals. Perturbations, investigation of star places and differential reduction to apparent place have been neglected. Perhaps the similarity of this orbit to those of (293) *Brasilia*, 1906 *WF* and 1911 *LU*, should be investigated; but in case it proves to be new, Mr. Peters suggests the name *Washingtonia*.

Elements

Epoch = 1918 Jan. 0.5 G. M. T.

$e = 0.281411$ $m_0 = 13.5$

$\log a = 0.500543$ $g = 9.3$

$\mu = 629''.786$

$M = 36° \; 11' \; 5''.3$

$$\left.\begin{array}{rl} i = & 16° \; 40' \;\; 9''.9 \\ \Omega = & 60 \;\; 55 \;\; 36 \;.4 \\ \omega = & 296 \;\;\; 3 \;\; 26 \;.5 \end{array}\right\} 1917.0 \qquad \begin{array}{r} \text{Reduction to 1918.0} \\ +\;0''.2 \\ +48\;.8 \\ +\;1\;.5 \end{array}$$

Constants for Equator (1917.0)

$$x = r\,[9.985904] \sin(\;85° \; 55' \; 40''.1 + v)$$
$$y = r\,[9.934855] \sin(\;\;4 \;\; 44 \;\; 20 \;.2 + v)$$
$$z = r\,[9.753954] \sin(333 \;\; 51 \;\; 22 \;.9 + v)$$

Constants for Equator (1918.0)

$$x = r\,[9.985899] \sin(\;85° \; 56' \; 31''.1 + v)$$
$$y = r\,[9.934871] \sin(\;\;4 \;\; 45 \;\; 12 \;.3 + v)$$
$$z = r\,[9.753926] \sin(333 \;\; 51 \;\; 55 \;.0 + v)$$

U. S. Naval Observatory, Washington, D. C., 1918, Jan. 15.

EPHEMERIS OF WOLF'S OBJECT,

By FRANK E. SEAGRAVE.

STRAEKE'S ELEMENTS.

$$\begin{aligned} E &= \text{Feb. } 3.500 \text{ G. M. T.} \\ M &= 7^\circ\, 34' \\ \pi &= 98^\circ\, 40' \\ \text{☊} &= 110^\circ\, 54' \\ i &= 8^\circ\, 58' \\ \varphi &= 32^\circ\, 12' \\ \mu &= 881''.50 \\ \text{Log } a &= 0.40319 \\ \text{Log } q &= 0.07263 \\ P &= 4.02 \text{ years} \end{aligned}$$

An ☍ taking place on December 30 of any year would bring this pretty near the *Earth*, 0.19 of a unit.

CONSTANTS

$$\begin{aligned} x &= r\,(9.99535)\ \sin\,(201^\circ\ 8'\ 10'' + u) \\ y &= r\,(9.97297)\ \sin\,(114^\circ\ 12'\ 26'' + u) \\ z &= r\,(9.57028)\ \sin\,(\ 89^\circ\ 34'\ 31'' + u) \end{aligned}$$

1918	α	δ	log r	log Δ
	h m s	° ′ ″		
Apr. 1	9 27 2	+31 26 6	0.18388	9.87305
5	9 35 16	+30 30 16	0.19112	9.89885
9	9 43 17	+29 33 10	0.19834	9.92408
13	9 51 5	+28 35 8	0.20550	9.94865
17	9 58 44	+27 35 29	0.21264	9.97275
21	10 6 14	+26 36 19	0.21968	9.99614
25	10 13 35	+25 36 16	0.22668	0.01901

L'ÉPHÉMÉRIDE DE LA COMÈTE WOLF, CALCULÉE POUR LA PERIODE 1918 JANVIER 1.0 — 1918 JUILLET 5.0.

By M. KAMENSKY.

Le système k_8' des éléments, pris pour base des calculs préparatoires pour la formation de l'éphéméride, est celui, qui a été déduit par moi de la liaison préalable des 5 retours de la comète vers le *Soleil* durant 1884–1911; il les satisfait bien. Ce système k_8' est déjà établi dans la Partie V de mes "Recherches sur le Mouvement de la Comète WOLF"; elle se trouve actuellement, avec la Partie IV, sous presse dans l'imprimerie de l'Académie des Sciences de Russie:

1912 Février 11.0 T. M. Berlin

$$k_8' \ldots\ldots \begin{aligned} M &= 358^\circ\ \ 9'\ \ 3''.30 \\ \varphi &= \ 33\ \ 55\ \ \ 2\ .22 \\ &\left.\begin{aligned} \text{☊} &= 206\ \ 37\ \ 53\ .32 \\ \pi &= \ 19\ \ 27\ \ 57\ .40 \\ i &= \ 25\ \ 15\ \ 57\ .06 \end{aligned}\right\}1910.0 \\ n &= 521''.48030 \end{aligned}$$

Avec l'aide de ce système, j'ai calculé les valeurs des perturbations du premier ordre, produites par *Jupiter* et *Saturne* durant la période 1912 Février 11.0 – 1918 Janvier 10.0, savoir

	Jupiter	*Saturne*
δM	−0′ 47″.77	+0′ 27″.73
$\delta\varphi$	+4 0 .09	−0 30 .05
δ☊	−3 5 .72	−0 1 .65
$\delta\pi$	+1 55 .02	−0 22 .01
δi	+1 49 .07	−0 11 .41
δn	+0″.98905	−0″.04745

En ajoutant ces perturbations au système k_8', j'ai formé le système suivant des éléments, sur lesquels l'éphéméride est fondé:

1918 Janvier 10.0 T. M. Berlin

$$\begin{aligned} M &= 311^\circ\ \ 2'\ \ 0''.71 \\ \varphi &= \ 33\ \ 58\ \ 32\ .26 \\ &\left.\begin{aligned} \text{☊} &= 206\ \ 34\ \ 45\ .95 \\ \pi &= \ 19\ \ 29\ \ 30\ .41 \\ i &= \ 25\ \ 17\ \ 34\ .72 \end{aligned}\right\}1910.0 \quad \left.\begin{aligned} \text{☊} &= 206^\circ\ 41'\ 32''.32 \\ \pi &= \ 19\ \ 36\ \ 12.\ 03 \\ i &= \ 25\ \ 17\ \ 31\ .54 \end{aligned}\right\}1918.0 \\ n &= 522''.42190 \end{aligned}$$

Les coördonnées rectangulaires héliocentriques équatoriales pour l'équinoxe moyen de l'année 1918.0 sont données par les formules:

$$\begin{aligned} x &= r.[9.991851]\ \sin\,(107^\circ\ 21'\ 24''.5 + f) \\ y &= r.[9.999980]\ \sin\,(\ 17\ \ 14\ \ 56\ .3 + f) \\ z &= r.[9.283648]\ \sin\,(104\ \ 25\ \ 53\ .7 + f) \end{aligned}$$

et le passage de la comète au périhélie aura lieu le 13 Décembre, 1918.

Il faut mentionner ici, que l'éphéméride offré n'est que la suite immédiate de l'éphéméride pour la seconde moitié de l'année 1917, qui fut présentée par moi en Juillet 1917 à l'Observatoire Central Nicolas à Poulkovo, pour être publiée. Mais, quoique les ordres d'imprimer furent donnés en ce temps — là par M. le Directeur de l'Observatoire Prof. A. BÉLOPOLSKY, — je ne sais rien, jusqu'à présent, à propos de la publication. J'en suis sûr, que les évenements qui s'écoulent actuellement en Russie, peuvent expliquer suffisamment le retard mentionné pour l'impression de mes articles.

L'apparition de la comète en 1918–1919 aura une grande analogie avec celle de 1884–1885, alors que la comète fut découverte par M. le PROF. M. WOLF. En même temps, l'apparition prochaine sera bien favorable pour les observations de la comète, vu que sa position au ciel sera très commode et la distance entre la comète et la *Terre* sera comparativement petite.

Comme pendant le calcul de l'éphéméride les perturbations de *Mars* et de la *Terre* n'ont pas été prises en considération, et également pour la raison que l'éphéméride a été calculée avec un système constant des éléments pour 1918 Janvier 10.0, nous pouvons attendre quelques écarts, quoique insignifiants, entre les calculs et les observations.

Ephéméride pour 0ʰ *T. M. Greenwich.*

1918	α_{vera}	Diff.	δ_{vera}	Diff.	log r	log Δ	Temps d 'ab.
	h m s	m s	° ′ ″	′ ″			m s
Mars 1	19 2 4.2	+2 41.7	− 2 48 49	+15 17	0.4733	0.5329	28 21
3	19 4 45.9	+2 40.8	− 2 33 32	+15 45	0.4716	0.5288	28 4
5	19 7 26.7	+2 39.9	− 2 17 47	+16 10	0.4699	0.5245	27 48
7	19 10 6.6	+2 38.6	− 2 1 37	+16 37	0.4681	0.5202	27 31
9	19 12 45.2	+2 37.7	− 1 45 0	+17 3	0.4664	0.5158	27 15
11	19 15 22.9	+2 36.5	− 1 27 57	+17 30	0.4646	0.5114	26 58
13	19 17 59.4	+2 35.5	− 1 10 27	+17 56	0.4629	0.5068	26 41
15	19 20 34.9	+2 34.4	− 0 52 31	+18 22	0.4611	0.5022	26 24
17	19 23 9.3	+2 33.1	− 0 34 9	+18 48	0.4594	0.4975	26 7
19	19 25 42.4	+2 31.8	− 0 15 21	+19 13	0.4575	0.4928	25 50
21	19 28 14.2	+2 30.4	+ 0 3 52	+19 41	0.4557	0.4880	25 33
23	19 30 44.6	+2 28.8	+ 0 23 33	+20 5	0.4539	0.4831	25 16
25	19 33 13.4	+2 27.5	+ 0 43 38	+20 31	0.4521	0.4781	24 58
27	19 35 40.9	+2 26.0	+ 1 4 9	+20 58	0.4503	0.4731	24 42
29	19 38 6.9	+2 24.4	+ 1 25 7	+21 23	0.4485	0.4680	24 25
31	19 40 31.3	+2 22.7	+ 1 46 30	+21 50	0.4466	0.4629	24 7
Avr. 2	19 42 54.0	+2 21.1	+ 2 8 20	+22 14	0.4448	0.4576	23 50
4	19 45 15.1	+2 19.4	+ 2 30 34	+22 41	0.4429	0.4523	23 33
6	19 47 34.5	+2 17.4	+ 2 53 15	+23 4	0.4410	0.4469	23 16
8	19 49 51.9	+2 15.6	+ 3 16 19	+23 30	0.4391	0.4415	22 58
10	19 52 7.5	+2 13.6	+ 3 39 49	+23 54	0.4372	0.4360	22 40
12	19 54 21.1	+2 11.6	+ 4 3 43	+24 17	0.4352	0.4305	22 23
14	19 56 32.7	+2 9.5	+ 4 28 0	+24 42	0.4333	0.4248	22 5
16	19 58 42.2	+2 7.1	+ 4 52 42	+25 4	0.4314	0.4191	21 48
18	20 0 49.3	+2 4.9	+ 5 17 46	+25 29	0.4295	0.4133	21 31
20	20 2 54.2	+2 2.4	+ 5 43 15	+25 50	0.4275	0.4075	21 14
22	20 4 56.6	+2 0.1	+ 6 9 5	+26 14	0.4255	0.4016	20 57
24	20 6 56.7	+1 57.5	+ 6 35 19	+26 34	0.4235	0.3957	20 40
26	20 8 54.2	+1 55.0	+ 7 1 53	+26 56	0.4215	0.3897	20 23
28	20 10 49.2	+1 52.2	+ 7 28 49	+27 18	0.4195	0.3837	20 6
30	20 12 41.4	+1 49.6	+ 7 56 7	+27 37	0.4175	0.3778	19 49
Mai 2	20 14 31.0	+1 46.6	+ 8 23 44	+27 57	0.4155	0.3714	19 32
4	20 16 17.6	+1 43.8	+ 8 51 41	+28 17	0.4135	0.3652	19 15
6	20 18 1.4	+1 40.5	+ 9 19 58	+28 34	0.4115	0.3589	18 59
8	20 19 41.9	+1 37.2	+ 9 48 32	+28 51	0.4094	0.3526	18 42
10	20 21 19.1	+1 33.9	+10 17 23	+29 9	0.4072	0.3463	18 26
12	20 22 53.0		+10 46 32		0.4052	0.3399	18 9

1918		α_{vera}	Diff.	δ_{vera}	Diff.	log r	log Δ	Temps d' ab.
		h m s	m s	° ′ ″	′ ″			m s
Mai	12	20 22 53.0	+1 30.4	+10 46 32	+29 22	0.4052	0.3399	18 9
	14	20 24 23.4	+1 26.8	+11 15 54	+29 36	0.4031	0.3334	17 54
	16	20 25 50.2	+1 23.2	+11 45 30	+29 48	0.4010	0.3269	17 38
	18	20 27 13.4	+1 19.4	+12 15 18	+30 1	0.3988	0.3204	17 22
	20	20 28 32.8	+1 15.6	+12 45 19	+30 10	0.3967	0.3138	17 6
	22	20 29 48.4	+1 11.5	+13 15 29	+30 18	0.3946	0.3072	16 51
	24	20 30 59.9	+1 7.6	+13 45 47	+30 26	9.3925	0.3006	16 36
	26	20 32 7.5	+1 3.3	+14 16 13	+30 32	0.3903	0.2939	16 21
	28	20 33 10.8	+0 58.9	+14 46 45	+30 36	0.3881	0.2872	16 6
	30	20 34 9.7	+0 54.4	+15 17 21	+30 37	0.3859	0.2805	15 51
Juin	1	20 35 4.1	+0 49.8	+15 47 58	+30 37	0.3837	0.2738	15 36
	3	20 35 53.9	+0 45.0	+16 18 35	+30 35	0.3815	0.2670	15 22
	5	20 36 38.9	+0 40.1	+16 49 10	+30 31	0.3793	0.2602	15 7
	7	20 37 19.0	+0 35.1	+17 19 41	+30 22	0.3771	0.2534	14 53
	9	20 37 54.1	+0 29.7	+17 50 3	+30 9	0.3749	0.2466	14 38
	11	20 38 23.8	+0 24.5	+18 20 12	+29 57	0.3726	0.2398	14 24
	13	20 38 48.3	+0 19.0	+18 50 9	+29 39	0.3704	0.2330	14 11
	15	20 39 7.3	+0 13.6	+19 19 48	+29 18	0.3681	0.2262	13 59
	17	20 39 20.9	+0 8.0	+19 49 6	+28 55	0.3658	0.2194	13 46
	19	20 39 28.9	+0 2.2	+20 18 1	+28 30	0.3635	0.2127	13 34
	21	20 39 31.1	−0 3.4	+20 46 31	+27 59	0.3613	0.2060	13 21
	23	20 39 27.7	−0 9.1	+21 14 30	+27 25	0.3590	0.1993	13 9
	25	20 39 18.6	−0 14.8	+21 41 55	+26 46	0.3567	0.1926	12 57
	27	20 39 3.8	−0 20.6	+22 8 41	+26 4	0.3543	0.1860	12 45
	29	20 38 43.2	−0 26.4	+22 34 45	+25 16	0.3520	0.1794	12 33
Juill.	1	20 38 16.8	−0 32.2	+23 0 1	+24 25	0.3497	0.1729	12 22
	3	20 37 44.6	−0 38.0	+23 24 26	+23 26	0.3474	0.1664	12 11
	5	20 37 6.6		+24 47 52		0.3450	0.1599	12 0

1917, Decembre, Vladivostok, l'Observatoire Naval.

ABSOLUTE PARALLAX OF *POLARIS*,

By A. ESTELLE GLANCY.

So far as is known to the writer, the series of declinations of *Polaris* made by BONSDORFF at Odessa, (1908–1910), have not been used for a determination of the parallax of *Polaris*. This series offers abundant pairs of upper and lower culminations and the solution is of some interest as regards the constant of abberration and the variation of refraction.

The observations are found on pp. 6, 31, *loco. cit.* They are in the form of zenith distances reduced to 1910.0 using Paris constants, Pulkowa refractions and the adopted proper-motions. Aside from the errors of observation, they may contain errors of reduction in precession, nutation, aberration, proper-motion and refraction and displacements due to variation of latitude and parallax. If we use pairs of upper and lower culminations and take the differences upper − lower, the correction for variation of latitude is eliminated, the correction for refraction becomes a differential and can be treated as a constant, and the parallactic displacement is doubled. The nutation correction is neglected. A correction to annual variation was introduced into the solution and found to be negligible. Hence the condition equations to be satisfied by the given observations contain aberration, parallax and a constant.

Now the displacements due to aberration and parallax are related in phase and numerical coefficients. They contain the same numerical coefficients and differ in phase by 90°.

Let the displacement in declination due to parallax be P_δ, the absolute parallax be π, and the longitude

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Publ. de l'Observatoire Central Nicolas, Series II, Vol. XXIV, 1913. Obs. faites au Cercle Vertical de Repsold a la Sucursale Odessa pour la Determination de la Refraction.

of the *Sun* be ⊙. Then for *Polaris*

$$P_\delta = 0.986\,\pi \sin (289^\circ.6 - \odot)$$

and by analogy, the aberration terms in the reduction to apparent declination are

$$0.986A \sin (199^\circ.6 - \odot) \qquad A = -20''.47$$

The equations of condition become

$$2NPD\,(1910.0) = 2NPD\,(\text{obs.}) - 1.972a \sin (199^\circ.6 - \odot) + 1.972\,\pi \cos (199^\circ.6 - \odot) + c$$

where

$$a = \text{corr. to } -A \qquad c = \text{constant}$$

In the total number of observations there are one hundred and sixty pairs of upper and lower culminations. The solution by least squares gave

$$a = +0''.102 \qquad \pi = +0''.063$$

The constant was eliminated by subtracting the mean equation from each equation.

The parallax agrees well with previous determinations, but the correction to the constant of aberration is doubtful. Following is the evidence against its reality.

In the consideration of parallax and aberration we have to do with a function of the form

$$a \sin \odot + b \cos \odot$$

This is so common a form of periodic variation that the fact should be emphasized that anything of this nature can, in general, be resolved into two sine functions with phases differing by 90°, or that any such periodic variation will, in general, produce a fictitious parallax and a fictitious correction to the constant of aberration.

Reversing the order by building up the resultant from two components at right angles, say parallax and aberration, the resultant is a sine curve whose phase lies between the phases of each taken separately.

Tabulating monthly means of $2NPD$ it is found that the curve has its maximum and minimum points about April and October respectively. So far this indicates nothing but parallax. Now in July, 1908, there is a very low drop in the curve, and July is a minimum point for a positive correction a. Observations in January are too few to give the maximum point. Now, if the correction to the constant of aberration were real, the curve should be a smooth sine curve within the error of observation and the maximum point should fall between January and April. Since the maximum and minimum points fall satisfactorily near the theoretical ones for parallax, and the sine curve is made ragged by the July observations, and January is not represented, we can conclude that the correction to the constant of aberration is fictitious, and due to some unknown cause which has introduced discordant values at a maximum point of the aberration curve.

This example of a fictitious correction to the constant of aberration leads me to think that there may be other cases of this kind. Some determinations of differential parallax have yielded corrections of this order and the hypothesis has been proposed that the velocity of light proceeding from the parallax star differs from the velocity of light proceeding from the comparison stars.* We also have considerable range in the determinations of the constant of aberration† and the parallax of a star. The accuracy of observation has reached a high standard, but we are not yet free from systematic errors of obscure source. It is generally conceded that the real uncertainty of a quantity is larger than its probable error indicates and that a better measure of its weight is the comparison of independent determinations by different observers at different times, at different places, with different instruments and by different methods. We have too, in general, such a program of observation and such an arrangement of data for reduction that the quantity sought shall be extracted with the greatest possible accuracy and that other unknowns shall enter with as little influence as possible. Hence, for example, a solution for differential parallax may be made to include a correction to proper-motion, but we cannot look upon it as real for we have restricted the element of time. It is better to attribute such correction to accident or to some possibly real but unknown cause. In view of these facts, it seems at present unnecessary to construct a hypothesis to explain a variability of the constant of aberration and sufficient to ascribe the appearance of variability to a chance distribution of residuals or to any real unknown periodic cause which varies with the longitude of the *Sun*.

A second solution of the observations was made, using only the dates March 1 to May 6, Aug. 31 to Nov. 25, thereby limiting the arc to 43 days on either side of the maximum and minimum points of the

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*Bohlin, *B. A.*, March, 1913, p. 113.

†Chandler, *A. J.*, Vols. XII, XIII.

parallax curve and reducing the number of equations to 73. The omitted dates add little or nothing to the weight of the parallax, for the factors are very small. The correction to the constant of aberration can be assumed equal to zero, and even if it were not, it could influence the result very little for the aberration is zero when the parallax is a maximum. This solution gives

$$\pi = +0''.086 \pm 0''.033$$

and is to be preferred.

It remains to explain why Bonsdorff found no difference in zenith distance in the sense day minus night. He was not interested in the parallax but in the daily variation of refraction. From a table of zenith distances, which he calls definitive, he took the means in two groups, 6 A. M. to 6 P. M. and 6 P. M. to 6 A. M. For *Polaris* the difference is zero.

Now if *Polaris* has a parallax of 0″.086 we should find a difference day minus night equal to $-0''.17$ multiplied by the mean $\cos(199.6 - \odot)$. From pp. [83] and [93] the definitive zenith distances were taken for the same limiting dates as in the revised solution. This selection should give day minus night $= -0''.16$. It gives

	Mean Day − Night
upper	−0″.14
lower	−0 .12
	−0″.13

If we include all the dates the mean cosine factor is about 0.6 and the difference should be about −0″.10. Since Bonsdorff finds it to be zero, I conclude that it is due to the influence of the omitted dates.

This brings us to the relation between parallax and variation of refraction.

Parallax displacement in declination can be put in several forms.

Let P_δ be the parallax displacement in declination. Let ⊙ be longitude of *Sun*. Let L be the longitude of the *Sun* when its R. A. differs from that of the star by 180°. Let A be the inclination of the ecliptic to the hour circle passing through L, measured from the north counter-clockwise. Let D be the declination of the *Sun* when at L.

$$\begin{aligned} P_\delta &= k \sin (K' - \odot) \\ k \cos K &= \pi \cos A \cos (\delta + D) \\ k \sin K &= \pi \sin (\delta + D) \\ K' &= K + L \end{aligned}$$

or the two alternate forms

$$\begin{aligned} P_\delta &= \pi \sin \delta_\odot \cos \delta_* - \pi \cos \delta_\odot \sin \delta_* \cos (\alpha_\odot - \alpha_*) \\ P_\delta &= \pi (\cos \delta_* \sin \epsilon - \sin \delta_* \sin \alpha_* \cos \epsilon) \sin \odot \\ &\quad - \pi \sin \delta_* \cos \alpha_* \cos \odot \end{aligned}$$

Stars near the equator and ecliptic are the poorest for the determination of parallax from the declination; those near the poles are the best.

The displacement for equatorial stars reduces to

$$P_\delta = 0.4\, \pi \sin \odot$$

Hence the maximum displacement for equatorial stars is only 0.4π and occurs when the *Sun* is at the solstices. Being independent of R. A., all equatorial stars are displaced 0.4π at these times.

Stars on the ecliptic have their total displacement along the ecliptic. The maximum displacement in declination for a zodiacal star is 0.4π and occurs if the *Sun* is at a solstice and the star at an equinox. For all others it is less and the displacement for stars culminating at midnight and noon is zero.

A star at the north pole of the equator is displaced the full amount of its parallax when the *Sun* is at an equinox. Close circumpolars are displaced nearly their full amount toward the pole when upper culmination occurs near midnight, thereby increasing the apparent zenith distance at night and diminishing it by day. Six months later upper culmination occurs at noon, the displacements are away from the pole, thereby diminishing the apparent zenith distance by day and increasing it by night.

A star at the north pole of the ecliptic is also displaced by the full amount of its parallax when the *Sun* is at a solstice and the culminations are at midnight and noon.

In general, the nearer the stars to the poles of the equator and ecliptic, the greater is the maximum displacement and the nearer the maximum displacement occurs at midnight or noon meridian passage, the apparent zenith distance being increased by night and diminished by day.

Let us suppose that there is no parallax, but that the constant of refraction is too large for night observations and too small for day work. The zenith distance, corrected for refraction, is then too large by night and too small by day. Parallax and variation of refraction are not identical for midnight parallactic displacement changes sign at the ecliptic, and refraction changes sign at the zenith, but it is clear that these two displacements will be confused unless special precautions are taken, the only condition being that the parallax is large enough to be appreciable.

Recent investigations by meridian circle observers have shown a diurnal change in refraction. The results of four investigators are accessible. Three of these find the minimum refraction comes near midnight, the fourth that the night refraction is smaller than the day value.

The most complete study has been made by Tucker at the Lick Observatory.[*] The result of his work can be stated, in general terms, to be the establishment of a daily variation in the constant of refraction amounting to 0″.5 in total range, the minimum being near midnight, the maximum near noon and the mean values near sunset and sunrise.

In *A. J.*, No. 697, A. J. Roy has published for the San Luis declinations a short table of refraction factors for different parts of the day. Quoting from this article, it is found "that about sunset the refraction decreases rapidly, that the decrease continues throughout the night, perhaps even for some appreciable time after sunrise, that the increase does not begin at dawn that it is moderate for an hour or more after sunrise and then is quite rapid." The total range in the constant of refraction is about 0″.7 in eighteen hours.

A less complete study is contained in the Pulkowa volume under consideration. The Bonsdorff determination is only for the night hours. He too reaches the conclusion that the refraction is smallest near midnight, but the total range in twelve hours is only 0″.09. He also finds a yearly variation with a range of 0″.16.[†]

On page [70] Bonsdorff refers to Kudrjawzew's previous results with the same instrument at the same place. The observations were taken for the formation of the Odessa Catalog of 1900. He found a minimum refraction at 14 hours M. T., a half daily amplitude of 0″.2 and a yearly range of about 0″.35.[†]

I have come across but one statement in these investigations referring to the relation between parallax and refraction. Bonsdorff, (page 107), states that the parallax of α *Aquilæ* (0″.20) has been taken into account in the difference day minus night.

If we sum up the results of these four investigators it is at once evident that they show in common the smallest refraction at some time during the night, that they differ considerably among themselves, and that, with the exception of Bonsdorff, the amplitude is too large to be attributed to parallax alone. Tucker's observations cover most nearly the twenty-four hours of the day and his results most closely follow the parallax curve, but the coefficient is too large to be explained by parallax alone.

I attribute the neglect of parallax in these studies to the assumption that it is too small to be appreciable. It is not intended to assert that Tucker's or Roy's or Kudrjawzew's results would be materially changed by a consideration of the parallax, but it is urged that, in view of the high accuracy of observation now attainable and the exhaustive series of observations and careful discussions which are made, the relation between these two displacements should be held in mind. We have to remember that our estimate of stellar distances is based on differential parallax which cannot be larger and may be smaller than absolute parallax and that some of the bright stars may have as yet unmeasured parallaxes.

Since *Polaris* is an excellent refraction star, we can profitably compare its parallactic displacement with a variable refraction.

(Tucker) Lick Obs. Meridian Passage at Midnight.

Displacement north owing to daily variation in refraction		$-0''.2tg52^\circ = 0''.25$
Displacement north owing to	$(\pi = 0''.086)$	$= 0''.08$

(Bonsdorff) Odessa, Meridian Passage at Midnight.

Displacement north owing to daily variation in refraction		0″.03
Displacement north owing to	$(\pi = 0''.086)$	0″.08

It is to be noted that Bonsdorff did not use *Polaris* in the determination of the daily variation.

Not only can parallax cause an apparent daily variation in refraction but also a yearly term (probably smaller).

In *Astr. Jahr.* 2, 105 there is a reference to a paper in *Wien Ber.* 109, 578 by Egon V. Oppolzer entitled, *Ueber den Zuzammenhang von Refraction und Parallax*, and the statement that Hansen first called attention to the fact that refraction, rigidly taken, depends not only upon the apparent zenith distance, but also upon the distance of the heavenly body. This paper is not in our library.

I owe the suggestion of the relation of parallax to variation in refraction to Astronomer Zimmer of this Observatory.

Observatorio Nacional, Cordoba, Argentina, November 22, 1917.

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[*] *L. O. B.*, Nos. 231, 292.

[†] Note. It is not impossible that this variation would be somewhat modified by the instrumental error of this instrument which was later found to be of the form $c \sin 2Z$. See *Mitteilungen der Nikolai-Hauptsternwarte zu Pulkowa*, No. 56.

NOTE REGARDING 1903 *NF*,

[Communicated by Rear Admiral T. B. Howard, U. S. N., Superintendent of the Naval Observatory.]

By GEORGE H. PETERS.

Dr. A. E. Glancy in *Ast. Jour.* 723 gives some interesting facts in regard to a new determination of the elements of this asteroid.

This object was discovered by the writer with the 6-inch Dallmeyer lens of 39 inches focal length, then attached to the 26-inch equatorial.

At that time, and with this comparatively poor apparatus, only approximate photographic positions were published, as micrometer observations were depended upon for accurate places.

The original reductions, however, were carried out to the same number of decimals as given for the Gesselschaft comparison stars. The plate of [1903 *NF*] of December 11 has just been remeasured, using the comparison stars previously employed. An additional comparison star, No. 5, was also introduced.

The second reduction was made by a method different from the original one, and of somewhat greater refinement. In order to show the comparative value of these results the reductions from the latest measures of this plate are given in detail. It is suggested that additional photographic observations might be found at other observatories on plates of this region taken at about this epoch.

Should this be the case the writer would gladly undertake the measurement and reduction of the same at the Naval Observatory, provided the plates were not over ten inches square, which is the limit of size for the Stackpole measuring engine.

Asteroid	Date 1903	Wash. M. T.	α 1903.0	δ 1903.0	Remarks
			h m s	° ′ ″	
[1903 *NF*]	Dec. 11	10 32.5	5 45 58.40	+9 37 28.5	Mean of measures using 4 stars, made in 1903.
[1903 *NF*]	Dec. 11	10 32.5	5 45 58.39	+9 37 28.9	Stars 2 and 3.
[1903 *NF*]	Dec. 11	10 32.5	58.50	26.8	Stars 3 and 4.
[1903 *NF*]	Dec. 11	10 32.5	58.48	27.8	Stars 1 and 4.
[1903 *NF*]	Dec. 11	10 32.5	58.42	28.1	Stars 2 and 5.
			5 45 58.45	+9 37 27.9	Mean of second set of measures, made in 1918.

NEW ASTRONOMICAL WORK.

Aggiunte al Catalogo dell' Atlas Stellarum Variabilium, by J. G. Hagen S. J., Specola Astronomica Vaticana XI. Rome, 1916.

Eine Studie uber die Analyse der Sternbewegungen, by C. V. L. Charlier. Meddelande fran Lunds Astronomiska Observatorium. Band 12, No. 10, Lund, 1917.

Annales de l'Observatoire Astronomique de Tokyo. Tome V. Tokyo, 1917.

Statistical Mechanics Based on the Law of Newton, by C. V. L. Charlier. Meddelanden fran Lunds Astronomiska Observatorium. Series 11, No. 16. Lund, 1917.

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Elements of 1917 *W 15*, by Ernest Clare Bower and Charles Clayton Wylie.
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Note Regarding 1903 *NF*, by George H. Peters.
New Astronomical Work.

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OBSERVATIONS OF ASTEROIDS AND COMETS,

MADE WITH THE 12-INCH EQUATORIAL AT THE NATIONAL ARGENTINE OBSERVATORY,

By A. ESTELLE GLANCY.

Date	Gr. M.T.	Δα	Δδ	No. of Comp.	App. α	App. δ	log pΔ		Red. to App. Pl.		⁎
					(105) *Artemis*						
1914	h m s	m s	′ ″		h m s	° ′ ″			s	″	
Jan. 27	13 31 37	−0 13.29	+2 01.5	12 , 8	6 49 59.38	− 8 53 36.8	9.180*n*	0.530*n*	+1.73	+ 1.7	29
27	14 18 02	−0 20.05	−0 50.8	11 , 10	6 49 57.74	− 8 53 22.3	8.693*n*	0.525*n*	+1.72	+ 1.7	*m*
					(10) *Hygiea*						
Feb. 1	13 54 10	−0 3.74	−7 48.6	8 , 9	2 54 13.52	+19 31 12.6	9.623	0.766*n*	+0.58	+10.3	*c*
8	13 06 35	−0 16.10	−5 20.4	11 , 8	2 58 08.71	+19 39 09.3	9.583	0.781*n*	+0.52	+10.1	*d*
9	12 36 35	−0 11.01	−6 10.9	10 , 9	2 58 44.36	+19 40 34.5	9.529	0.796*n*	+0.50	+10.1	*e*
					(133) *Cyrene*						
Mar. 15	13 56 33	+0 19.06	+3 00.2	11 , 10	9 50 42.69	+10 22 00.2	8.945*n*	0.765*n*	+2.18	− 6.5	*aa*
					(115) *Thyra*						
Apr. 29	13 50 39	−0 42.74	−3 14.7	11 , 8	13 21 09.21	−27 40 28.8	9.280*n*	9.876*n*	+2.43	−19.5	35
30	13 29 26	+0 10.71	−0 45.5	10 , 9	13 20 13.40	−27 34 09.2	9.357*n*	9.935*n*	+2.42	−19.7	34
					(10) *Hygiea*						
1916 May 3	15 22 37	+0 35.46	+4 50.9	12*t*, 12	12 54 45.24	−11 59 04.7	9.107	0.470*n*	+2.93	−20.8	*aj*
7	14 02 42	−0 02.51	−4 25.6	9 , 9	12 52 49.48	−11 41 31.0	8.015*n*	0.469*n*	+2.94	−20.9	*ai*
8	11 38 20	+1 04.28	−1 44.4	10*t*, 10	12 52 25.57	−11 37 41.9	9.481*n*	0.511*n*	+2.93	−20.9	*ah*
					e 1913 (ZINNER-GIACOBINI)						
1913 Nov. 30	14 43 07	+0 24.93	−3 55.0	10 , 11	22 51 25.00	−36 41 39.0	9.746	0.211*n*	+3.71	+ 6.2	99
Dec. 2	13 18 52	+0 15.82	−3 14.5	11 , 9	23 06 08.54	−37 17 18.4	9.610	9.184*n*	+3.76	+ 6.8	101
					f 1913 (DELAVAN)						
Dec. 18	16 20 44	+2 10.32	−7 31.0	5*t*, 5	3 02 20.36	− 7 19 13.5	9.536	0.583*n*	+4.11	+19.3	5
26	14 21 08	+0 01.60	−1 02.4	11 , 8	2 55 45.27	− 6 29 28.6	9.279	0.574*n*	+4.06	+18.5	4
29	13 30 16	−1 26.28	+3 34.0	10*t*, 10	2 53 31.54	− 6 08 43.3	9.050	0.574*n*	+4.05	+18.5	3
1914 Jan. 16	13 21 49	+0 08.73	−2 29.4	10 , 10	2 43 15.14	− 3 41 49.0	9.414	0.617*n*	+0.82	+ 2.9	*b*
26	13 34 47	−2 40.64	−4 41.9	10*t*, 10	2 40 06.74	− 2 08 00.9	9.550	0.640*n*	+0.71	+ 2.8	1
1915 Jan. 25	20 20 01	+0 28.71	−1 13.0	11*t*, 11	17 17 58.81	−19 02 35.8	9.708*n*	0.561*n*	−0.10	− 8.3	63

f 1913 (DELAVAN) — (*Continued.*)

Date		Gr. M.T	$\Delta\alpha$	$\Delta\delta$	No. of Comp.	App. α	App. δ	log $p\Delta$		Red. to App. Pl.		$*$
1915		h m s	m s	′ ″		h m s	° ′ ″			s	″	
Feb.	20	20 36 31	−1 35.31	−4 27.6	9*t*, 9	17 43 27.30	−27 06 41.1	9.640*n*	0.277*n*	+0.63	− 6.9	70
	21	20 31 22	−1 37.37	−2 57.8	11*t*, 10	17 44 10.96	−27 25 17.2	9.644*n*	0.275*n*	+0.67	− 6.8	72
Mar.	12	19 16 46	−0 58.25	−6 25.6	11*t*, 11	17 53 23.24	−33 30 38.2	9.685*n*	0.134*n*	+1.38	− 4.7	79
	15	18 59 08	+2 52.15	+0 33.4	12*t*, 11	17 53 55.03	−34 30 37.4	9.698*n*	0.122*n*	+1.50	− 4.5	75
	18	18 40 26	−0 21.74	+7 19.5	13 , 10	17 54 08.58	−35 31 21.3	9.712*n*	0.123*n*	+1.59	− 4.0	80
	18	19 03 54	−0 21.42	+6 59.3	8*t*, 8	17 54 08.90	−35 31 41.5	9.680*n*	9.984*n*	+1.59	− 4.0	80
	20	20 19 03	+0 32.63	−8 33.7	11*t*, 11	17 54 07.20	−36 13 55.3	9.495*n*	9.205	+1.68	− 3.7	78
	25	20 08 08	+0 35.61	+0 14.1	8*t*, 8	17 53 24.02	−37 57 42.5	9.470*n*	9.697	+1.93	− 3.2	77
	30	19 26 00	+0 09.76	+7 22.9	12 , 10	17 51 41.79	−39 42 30.1	9.551*n*	9.713	+2.14	− 2.8	76
Apr.	24	17 03 29	−0 59.36	+2 11.3	10*t*, 10	17 25 15.34	−48 17 18.4	9.663*n*	0.150	+3.53	− 3.2	66
	27	15 55 33	+0 32.04	−1 18.7	12*t*, 12	17 19 56.66	−49 11 56.0	9.771*n*	9.817	+3.68	− 3.9	65
May	10	14 33 20	−0 22.99	+0 38.2	12*t*, 12	16 51 41.88	−52 35 19.1	9.807*n*	9.994	+4.38	− 7.6	61
	13	14 35 40	−1 47.66	−3 21.2	10*t*, 10	16 44 12.52	−53 12 04.8	9.776*n*	0.170	+4.50	− 8.5	60
	14	15 11 57	+0 37.22	+6 36.7	11*t*, 11	16 41 35.64	−53 23 31.4	9.681*n*	0.349	+4.56	− 9.2	59
	16	15 18 08	+0 01.77	−4 28.6	11 , 10	16 36 26.14	−53 44 35.0	9.628*n*	0.406	+4.63	−10.0	58
	17	13 47 37	+0 06.43	+4 40.8	11 , 10	16 33 59.71	−53 53 38.7	9.821*n*	0.050	+4.68	−10.4	57
	18	14 00 45	+1 36.54	−0 18.9	10*t*, 10	16 31 20.77	−54 02 59.9	9.790*n*	0.188	+4.71	−11.1	56
	31	11 42 18	−0 23.47	−5 03.3	10 , 10	15 57 42.35	−55 16 45.7	9.880*n*	9.718	+4.89	−16.9	53
June	1	12 16 38	+0 44.08	+4 34.8	11 , 10	15 55 09.35	−55 19 08.4	9.826*n*	0.153	+4.90	−17.6	52
	2	11 53 08	−0 55.50	−1 42.5	11 , 11	15 52 43.03	−55 21 07.3	9.852*n*	0.027	+4.90	−17.9	51
	22	12 31 21	−0 38.19	+2 03.2	10 , 10	15 11 51.19	−54 50 49.1	9.337*n*	0.522	+4.41	−25.2	49
	28	12 38 19	−1 37.59	−1 15.0	10*t*, 10	15 03 36.24	−54 25 46.5	8.830*n*	0.537	+4.29	−26.7	48
	30	12 45 44	−0 18.49	−2 56.7	11 , 10	15 01 12.69	−54 16 44.6	7.051*n*	0.536	+4.19	−27.3	45
July	5	12 33 50	−0 10.88	−0 15.9	10*t*, 10	14 56 05.51	−53 53 28.5	8.670	0.528	+4.00	−28.0	43
	6	13 05 36	+0 10.71	−4 39.3	10 , 10	14 55 11.18	−53 48 43.8	9.259	9.510	+3.95	−28.1	42
	8	13 02 33	−0 03.75	+0 30.2	10 , 10	14 53 32.97	−53 39 19.7	9.309	0.501	+3.91	−28.3	41
	18	13 35 07	−0 20.76	−2 19.3	10 , 10	14 47 52.78	−52 53 50.3	9.660	0.353	+3.60	−29.2	39
	19	12 58 36	−0 41.19	+1 48.8	11*t*, 11	14 47 32.33	−52 49 42.2	9.550	0.425	+3.58	−29.2	39
	28	12 16 52	+0 06.02	+3 04.5	10 , 11	14 45 53.97	−52 14 51.0	9.524	0.420	+3.37	−29.6	36
Aug.	2	11 49 34	−0 40.10	−2 23.6	10*t*, 10	14 46 02.64	−51 58 29.7	9.487	0.427	+3.23	−29.2	37
	11	13 39 11	−0 10.43	+1 04.9	10 , 10	14 47 58.10	−51 34 34.7	9.835	9.451	+3.06	−29.0	38
	26	12 30 30	+1 35.80	+2 04.8	9*t*, 10	14 54 57.78	−51 12 31.7	9.810	9.777	+2.77	−27.7	40
	31	12 41 51	−0 13.53	+1 02.6	10 , 10	14 58 10.43	−51 09 43.4	9.844	7.811*n*	+2.72	−27.0	44
Sept.	6	13 03 16	+0 29.93	+2 11.7	10 , 11	15 02 29.91	−51 09 09.7	9.878	9.981*n*	+2.65	−26.4	47
	7	13 00 52	+1 31.41	+3 03.4	11*t*, 11	15 03 15.89	−51 09 23.0	9.879	9.990*n*	+2.62	−26.3	46

e 1914 (CAMPBELL)

Date		Gr. M.T	$\Delta\alpha$	$\Delta\delta$	No. of Comp.	App. α	App. δ	log $p\Delta$		Red. to App. Pl.		$*$
1914												
Sept.	27	19 22 04	−0 35.35	+3 55.8	10 , 11	23 32 33.25	−38 04 24.6	9.739	0.091*n*	+4.85	+20.1	106
	28	16 27 29	−0 14.66	+7 21.3	9 , 10	23 20 06.50	−35 10 02.6	9.316	9.539	+4.76	+19.7	105
	29	11 52 33	−0 11.77	+5 53.1	12 , 11	23 10 09.24	−32 35 15.4	9.629*n*	0.007*n*	+4.67	+19.0	103
Oct.	1	12 29 58	−2 03.12	−0 54.4	10*t*, 10	22 50 02.25	−26 43 20.8	9.142*n*	0.055*n*	+4.46	+18.0	100
	4	11 38 11	−0 59.46	+5 48.5	12*t*, 12	22 28 49.12	−19 23 34.5	8.999	0.267*n*	+4.19	+17.1	*am*
	5	12 11 04	+0 55.11	+5 58.2	9*t*, 9	22 24 09.97	−17 36 19.4	9.328*n*	0.356*n*	+4.12	+16.9	97
	6	12 22 28	−1 38.75	+1 38.4	11*t*, 11	22 19 32.07	−15 45 43.2	9.226*n*	0.390*n*	+4.06	+17.1	96
	8	13 24 20	−2 19.99	+1 55.3	11*t*, 10	22 11 44.16	−12 29 11.9	7.699	0.452*n*	+3.95	+17.2	*al*
	9	12 39 28	−0 17.15	+3 09.6	11 , 10	22 08 39.62	−10 07 21.0	8.897*n*	0.503*n*	+3.90	+17.1	94

Date	Gr. M.T.	$\Delta\alpha$	$\Delta\delta$	No. of Comp.	App. α	App. δ	log $p\Delta$		Red. to App. Pl.		*
					a 1915 (MELLISH)						
1915	h m s	m s	′ ″		h m s	° ′ ″			s	″	
Feb. 20	20 00 25	−2 10.27	−1 15.6	10*t*, 10	17 15 53.89	+ 2 23 42.7	9.602*n*	0.676*n*	+0.61	−16.9	64
Mar. 12	20 29 53	+0 08.79	−7 10.6	10 , 11	17 41 07.35	+ 0 44 00.0	9.426*n*	0.667*n*	+1.13	−17.1	68
14	19 23 57	−0 28.34	−2 20.6	9 , 10	17 43 33.67	+ 0 32 42.6	9.566*n*	0.664*n*	+1.17	−17.0	69
14	19 43 53	−0 27.24	....	9 , ..	17 43 34.77	....	9.528*n*	....	+1.17	....	69
15	19 46 47	−0 14.83	−0 25.8	11 , 10	17 44 49.80	+ 0 26 36.5	9.516*n*	0.663*n*	+1.19	−16.9	71
15	20 06 16	−0 13.77	−0 30.6	12*t*, 11	17 44 50.86	+ 0 26 31.7	9.459*n*	0.664*n*	+1.19	−16.9	71
20	20 58 20	+0 22.72	+7 13.3	11 , 10	17 51 07.34	− 0 05 48.9	9.226*n*	0.658*n*	+1.30	−16.4	73
20	21 18 23	+0 23.85	+7 12.3	10*t*, 10	17 51 08.47	− 0 05 49.9	9.102*n*	0.658*n*	+1.30	−16.4	73
30	20 30 59	−0 37.97	+4 57.0	11*t*, 11	18 03 32.19	− 1 25 05.4	9.228*n*	0.642*n*	+1.54	−15.4	81
May 13	15 44 08	+0 59.02	−6 18.6	13*t* 12,	19 08 25.20	−21 54 21.4	9.688*n*	0.480*n*	+2.88	− 2.4	83
14	15 44 09	+1 45.89	+4 34.9	10*t*, 10	19 10 48.20	−23 08 09.0	9.690*n*	0.463*n*	+2.94	− 1.8	84
16	16 00 11	−0 45.98	+2 42.1	11*t*, 11	19 16 00.06	−25 50 21.4	9.680*n*	0.387*n*	+3.04	− 0.2	87
17	15 22 16	−0 35.28	−5 14.9	10*t*, 10	19 18 44.74	−27 15 56.3	9.720*n*	0.447*n*	+3.10	+ 0.4	88
19	22 23 06	−0 56.38	−1 25.3	9*t*, 9	19 25 53.75	−30 56 59.9	9.547	9.918*n*	+3.26	+ 2.1	*ak*
June 2	17 33 28	−1 36.39	+4 08.3	10*t*, 10	21 09 56.64	−62 28 21.7	9.904*n*	0.376	+4.88	+19.8	93
7	15 37 46	+1 40.64	−5 22.2	10 , 10	23 17 59.36	−72 07 16.8	0.200	0.493*n*	+3.66	+29.9	104
23	22 01 02	−0 17.37	+1 55.0	12 , 10	5 09 25.43	−57 15 10.6	9.960*n*	0.130*n*	−1.59	+13.7	6
24	22 13 55	+0 07.53	+6 47.5	12 , 11	5 14 51.52	−56 02 28.0	9.942*n*	0.047*n*	−1.49	+13.2	7
28	21 15 24	+0 03.83	−3 05.4	11 , 10	5 31 21.64	−51 44 49.6	9.908	0.479*n*	−1.07	+12.4	8
29	21 47 28	−1 31.01	−3 51.7	11*t*, 11	5 34 42.14	−50 44 57.6	9.896*n*	0.350*n*	−0.99	+12.2	9
July 2	21 40 23	−1 09.59	−3 12.8	10*t*, 10	5 42 59.41	−48 03 14.7	9.873*n*	0.400*n*	−0.78	+12.1	10
4	22 31 14	+1 04.80	−3 37.8	10*t*, 10	5 47 37.34	−46 23 54.2	9.837*n*	0.137*n*	−0.65	+12.3	11
5	22 06 31	−1 41.85	+3 38.5	11*t*, 11	5 49 38.11	−45 38 34.6	9.844*n*	0.290*n*	−0.61	+12.0	12
8	21 41 58	−0 15.28	+5 37.8	10 , 10	5 55 00.62	−43 30 42.3	9.835*n*	0.400*n*	−0.45	+12.2	*k*
14	21 54 42	+2 05.50	+0 33.5	11*t*, 11	6 03 25.95	−39 49 03.0	9.798*n*	0.341*n*	−0.14	+13.2	14
18	21 37 42	+0 26.70	+7 21.2	10*t*, 10	6 07 48.24	−37 42 26.4	9.788*n*	0.392*n*	0.00	+13.5	15
20	21 43 45	−0 36.65	−1 24.4	10*t*, 10	6 09 44.32	−36 43 43.2	9.776*n*	0.368*n*	+0.08	+13.5	17
21	22 03 31	+0 20.38	+0 54.1	12*t*, 12	6 10 39.79	−36 15 05.1	9.757*n*	0.284*n*	+0.13	+13.7	16
28	22 22 29	+1 10.29	+1 35.6	10*t*, 10	6 16 13.27	−33 14 27.6	9.699*n*	0.190*n*	+0.41	+14.9	18
30	22 15 42	+0 13.11	+5 40.2	10 , 11	6 17 35.49	−32 27 52.0	9.696*n*	0.214*n*	+0.46	+15.1	19
Aug. 11	22 11 52	+0 16.74	+0 59.9	10 , 10	6 24 12.62	−28 23 28.5	9.623*n*	0.204*n*	+0.88	+16.4	20
12	21 59 14	−0 44.42	+5 00.8	11*t*, 11	6 24 38.48	−28 05 38.0	9.637*n*	0.210*n*	+0.90	+16.5	23
16	21 47 18	−1 08.02	−3 11.4	11*t*, 11	6 26 11.72	−26 56 54.0	9.629*n*	0.265*n*	+1.02	+16.7	25
17	21 58 01	−1 11.23	+4 37.7	10*t*, 10	6 26 32.22	−26 40 17.7	9.603*n*	0.235*n*	+1.05	+16.8	27
20	21 30 55	+0 40.79	+0 54.2	10*t*, 10	6 27 26.33	−25 52 44.9	9.628*n*	0.297*n*	+1.18	+17.2	24
22	21 53 03	+0 27.56	+0 01.0	10*t*, 10	6 27 56.70	−25 21 57.4	9.574*n*	0.241*n*	+1.26	+17.4	26
Sept. 3	21 21 08	−0 32.73	−4 55.2	11*t* ,11	6 29 04.60	−22 37 18.2	9.532*n*	0.292*n*	+1.66	+18.0	28
16	21 21 28	−0 31.34	+6 03.7	11*t*, 11	6 25 44.22	−20 04 02.7	9.349*n*	0.290*n*	+2.13	+18.6	*l*
17	21 07 18	+0 00.64	+6 03.5	10 , 10	6 25 14.65	−19 53 00.4	9.391*n*	0.306*n*	+2.17	+18.7	22
					b 1915 (WINNECKE)						
Sept. 30	13 27 22	+0 34.23	−4 38.0	12*t*, 12	16 21 09.19	−30 19 51.8	9.759	0.525*n*	+2.81	−15.5	54
Oct. 1	13 11 31	−0 35.28	−0 15.1	13*t*, 13	16 26 38.03	−30 52 57.2	9.755	0.481*n*	+2.86	−15.4	55
7	12 17 44	−0 04.11	−7 10.9	11 , 11	17 00 44.30	−33 51 36.0	9.720	0.235*n*	+3.07	−14.4	62
28	12 44 14	+1 47.64	−2 58.4	10*t*, 10	19 06 45.70	−38 37 22.2	9.728	9.987*n*	+3.79	− 6.3	82
29	12 19 51	−0 02.18	−5 26.0	10 , 10	19 12 26.81	−38 37 38.7	9.691	9.733*n*	+3.83	− 5.7	85
30	12 51 16	+2 33.14	+0 44.1	11*t*, 11	19 18 18.09	−38 36 47.8	9.732	0.014*n*	+3.84	− 5.5	86

Date	Gr. M.T.	$\Delta\alpha$	$\Delta\delta$	No. of Comp.	App. α	App. δ	log $p\Delta$		Red. to App. Pl.		*
				b 1915 (WINNECKE) — (*Continued.*)							
1915	h m s	m s			h m s	° ′ ″			s	″	
Nov. 3	13 52 44	+2 35.99	+2 47.4	10*t*, 10	19 40 52.56	−38 23 22.5	9.782	0.313*n*	+3.89	− 3.7	90
6	13 08 54	−1 39.87	+2 26.4	11*t*, 11	19 56 48.19	−38 03 57.9	9.737	0.080*n*	+3.93	− 1.9	91
11	14 03 53	+0 39.79	+5 12.2	10*t*, 10	20 22 26.68	−37 15 31.1	9.776	0.336*n*	+3.98	+ 0.4	92
				c 1915 (TEMPLE)							
May 20	21 18 08	−1 12.42	+1 57.8	10*t*, 10	0 45 15.70	− 1 17 47.3	9.629*n*	0.650*n*	+0.91	+ 8.9	*a*
				e 1915 (TAYLOR)							
Dec. 6	14 18 04	−1 23.20	+4 22.0	10*t*, 10	5 22 46.27	+ 0 01 38.0	9.465*n*	0.659*n*	+4.94	+11.3	*j*
8	13 34 35	+0 11.85	−4 06.9	11*t*, 11	5 21 41.69	+ 0 22 46.0	9.544*n*	0.662*n*	+5.00	+11.3	*i*
9	14 03 54	+0 34.45	−6 30.4	11*t*, 11	5 21 06.95	+ 0 35 01.9	9.467*n*	0.665*n*	+5.02	+11.3	*h*
27	14 35 27	+0 56.09	−0 13.2	10*t*, 10	5 10 33.40	+ 5 50 22.3	8.817*n*	0.724*n*	+5.31	+10.7	*f*
28	13 50 18	−0 25.00	+1 40.7	10*t*, 10	5 10 05.58	+ 6 11 56.6	9.186*n*	0.724*n*	+5.32	+10.5	*g*
				a 1916 (NEUJMIN)							
1916											
Mar. 2	14 42 15	−0 47.78	−0 40.3	12*t*, 11	8 59 09.44	+12 43 21.9	8.278	0.784*n*	+2.73	− 8.0	*o*
3	14 26 41	−1 00.35	+6 49.6	11*t*, 10	8 59 25.37	+12 01 10.8	7.889*n*	0.780*n*	+2.72	− 8.2	*p*
4	12 44 02	+0 17.12	+2 44.5	12*t*, 12	8 59 43.50	+11 31 53.4	9.344*n*	0.765*n*	+2.70	− 8.2	*n*
8	13 16 07	−0 31.02	+2 55.2	11*t*, 11	9 01 31.40	+ 9 26 09.5	9.092*n*	0.755*n*	+2.65	− 8.8	*q*
8	18 01 55	−2 07.43	+6 46.7	10*t*, 10	9 01 36.25	+ 9 19 58.7	9.631	0.712*n*	+2.65	− 8.9	*s*
9	14 27 00	−2 09.29	+1 39.6	10*t*, 10	9 02 08.24	+ 8 53 55.9	8.577	0.753*n*	+2.64	− 9.0	*t*
10	14 12 12	−0 27.69	+5 07.9	15*t*, 14	9 02 45.54	+ 8 23 43.9	8.142	0.748*n*	+2.62	− 9.1	*r*
For observations, March 24 to April 6 inclusive, see following table.											
April 8	11 47 11	+0 35.97	+1 51.1	14*t*, 13	....	....	9.394	0.613*n*	+2.32	−14.4	
9	16 01 19	−1 57.61	−3 52.8	10*t*, 10	9 42 16.45	− 4 19 04.8	9.576	0.621*n*	+2.32	−14.6	*z*
22	12 35 41	−1 17.82	−7 59.3	11*t*, 11	10 07 49.93	− 8 09 58.6	8.488	0.538*n*	+2.26	−16.8	*ab*
30	15 16 16	−1 04.39	+9 54.6	10*t*, 10	10 25 20.72	−10 13 01.4	9.619	0.570*n*	+2.22	−18.0	*ac*
May 1	12 14 43	−1 57.90	−3 14.8	10*t*, 10	10 27 18.74	−10 25 18.0	8.936	0.498*n*	+2.23	−18.1	*ad*
3	12 56 27	+1 28.26	−3 07.6	11*t*, 11	10 31 46.46	−10 53 08.6	9.085	0.492*n*	+2.20	−18.3	*ae*
4	12 12 58	+0 07.57	−1 36.3	12 , 12	10 33 57.09	−11 06 16.7	8.440	0.482*n*	+2.22	−18.6	*af*
June 1	11 50 34	+0 16.01	+4 09.2	12*t*, 12	11 45 12.68	−16 51 04.3	8.958	0.347*n*	+2.34	−21.8	*ag*

OBSERVATIONS OF COMET *α 1916* (*NEUJMIN*),

MADE WITH THE 12-INCH EQUATORIAL AT THE NATIONAL ARGENTINE OBSERVATORY,

BY C. D. PERRINE.

Date	Gr. M.T.	$\Delta\alpha$	$\Delta\delta$	No of Comp.	App. α	App. δ	log $p\Delta$		Red. to App. Pl.		*
1916	h m s	m s			h m s	° ′ ″			s	″	
Mar. 24	13 06 04	+0 03.16	+1 50.0	18*t*, 18	9 16 36.20	+ 1 49 06.8	9.403*n*	0.678*n*	+2.44	−11.5	31
25	12 59 05	+0 38.49	−1 33.4	10*t*, 10	9 17 55.01	+ 1 23 20.8	9.418*n*	0.670*n*	+2.44	−11.8	32
26	13 00 32	−0 32.03	+1 52.8	13*t*, 15	9 19 17.05	+ 0 57 59.9	8.639*n*	0.670*n*	+2.44	−12.0	*u*
29	13 49 11	+2 04.05	+7 33.9	10*t*, 10	9 23 38.93	− 0 16 20.1	9.152*n*	0.656*n*	+2.41	−12.4	*v*
30	14 00 21	+1 13.34	+0 01.5	11*t*, 11	9 25 10.31	− 0 40 13.3	9.053*n*	0.651*n*	+2.40	−12.6	33
31	12 40 10	+1 49.66	−8 36.0	10*t*, 10	9 26 37.92	− 1 02 11.7	9.430*n*	0.648*n*	+2.38	−12.6	*w*
Apr. 1	12 46 30	−0 04.48	+3 04.2	10 , 8	9 28 13.36	− 1 25 19.3	9.103*n*	0.643*n*	+2.38	−13.0	*x*
6	14 07 44	+0 55.56	+4 41.6	10*t*, 10	9 36 43.45	− 3 16 06.6	8.902*n*	0.616*n*	+2.32	−13.9	*y*

*t signifies transits.

The observations by Professor Perrine were generously made during the writer's vacation. For the reductions the writer is responsible.

Mean Places of Comparison Stars for the Beginning of the Year.

*	Year	α	δ	Authority
		h m s	° ′ ″	
a	15	0 46 27.21	− 1 19 54.0	Comp. by transits with *A. G. Nicolajew* 153
b	14	2 43 05.59	− 3 39 22.5	*A. G. Strassburg* 670
c	14	2 54 16.68	+19 38 50.9	*A. G. Berlin A* 802
d	14	2 58 24.29	+19 44 19.6	Micr. comp. with *A. G. Berlin A* 818
e	14	2 58 54.87	+19 46 35.3	*A. G. Berlin A* 818
f	15	5 09 32.00	+ 5 50 24.8	*A. G. Leipzig* (2) 2068
g	15	5 10 25.26	+ 6 10 05.4	*A. G. Leipzig* (2) 2077
h	15	5 20 27.48	+ 0 41 21.0	*A. G. Nicolajew* 1300
i	15	5 21 24.84	+ 0 26 41.6	*A. G. Nicolajew* 1304
j	15	5 24 04.53	− 0 02 55.3	*A. G. Nicolajew* 1332
k	15	5 55 16.35	−43 36 32.3	*Argentine General* (1) 7092
l	15	6 26 13.43	−20 10 25.0	Bordeaux, Argelander Stars 1598
m	14	6 50 16.07	− 8 52 33.2	*A. G. Wien-Ottakring* 2250
n	16	8 59 23.68	+11 29 17.1	*A. G. Leipzig* (1) 3637
o	16	8 59 54.49	+12 33 10.2	*A. G. Leipzig* (1) 3640
p	16	9 00 23.00	+11 54 29.4	*A. G. Leipzig* (1) 3645
q	16	9 01 59.77	+ 9 23 23.1	Mean of Star 30 and *Toulouse Astr. Pl.* 68, Star 92
r	16	9 03 10.61	+ 8 18 45.1	*Toulouse Astr. Pl.* 68, Star 250
s	16	9 03 41.03	+ 9 13 20.9	*A. G. Leipzig* (2) 4970
t	16	9 04 14.89	+ 8 52 25.3	*A. G. Leipzig* (2) 4976
u	16	9 19 46.64	+ 0 56 19.1	Mean of *A. G. Nic.* 2858 and *Albany* 3765
v	16	9 21 32.47	− 0 23 41.6	*A. G. Nicolajew* 2867
w	16	9 24 45.98	− 0 53 23.1	*A. G. Nicolajew* 2878
x	16	9 28 15.46	− 1 28 10.5	*A. G. Nicolajew* 2885
y	16	9 35 45.57	− 3 20 34.3	*A. G. Strassburg* 3763
z	16	9 44 11.74	− 4 14 57.4	*A. G. Strassburg* 3820
aa	14	9 50 21.45	+10 19 06.5	*A. G. Leipzig* (1) 3892
ab	16	10 09 05.49	− 8 01 42.5	*A. G. Wien-Ottakring* 3931
ac	16	10 26 22.89	−10 22 38.0	*A. G. Cambridge U. S.* 3983
ad	16	10 29 14.41	−10 21 45.1	*A. G. Cambridge U. S.* 4000
ae	16	10 30 16.00	−10 49 42.7	*A. G. Cambridge U. S.* 4005
af	16	10 33 47.30	−11 04 21.8	*A. G. Cambridge U. S.* 4033
ag	16	11 44 54.33	−16 54 51.7	*A. G. Washington* 4614
ah	16	12 51 18.36	−11 35 36.6	*A. G. Cambridge U. S.* 4647
ai	16	12 52 49.05	−11 36 44.5	*A. G. Cambridge U. S.* 4654
aj	16	12 54 06.85	−12 03 34.8	*A. G. Cambridge U. S.* 4662
ak	15	19 26 46.87	−30 55 36.7	*Cordoba B* 12783
al	14	22 14 00.20	−12 31 24.4	*A. G. Cambridge U. S.* 7874
am	14	22 29 44.39	−19 29 40.1	Bordeaux, Argelander Stars 6636

The mean places of comparison stars determined from observations with the new Repsold Meridian Circle of the Cordoba Observatory will appear in the next number of the *Astronomical Journal*. (*A. J.*, No. 731.)

(105) *Artemis*

Jan. 27. *Mem. Nat. Acad. Sc.*, Vol. 10, Mem. 7, Corr. to Eph. $-1^{s}.1$ and $+22.''$
27. *Mem. Nat. Acad. Sc.*, Vol. 10, Mem. 7, Corr. to Eph. $-1^{s}.3$ and $+20.''$

(10) *Hygiea*

Feb. 9. Bright moon-light.

(133) *Cyrene*

Mar. 15. Faint. *Moon* rising.

(10) *Hygiea*

May 7. Through clouds.
May 8. Through clouds.

☄ *e* 1913 (Zinner-Giacobini)

Nov. 30. Recorded by E. P. Waterman.
Dec. 2. Recorded by E. P. Waterman.

☄ *f* 1913 (Delavan)

Dec. 18. Recorded by E. P. Waterman. Clouds. Re-reduced with new position of comparison star. This observation was used by Einarsson and Nicholson as the middle place in their first orbit. It is stated in *L. O. B.* 250 that the residuals $-10''$ and $+3''$ account for the relative uncertainty of the first orbit. The position of the comparison star has been doubly verified by re-observation at Cordoba and by the receipt of the astrographic position, for which I am indebted to Senor Don Tomas de Azcarate, Director del Observatorio de San Fernando. The inaccuracy is therefore to be ascribed to the interference by clouds which permitted only five transits.
Dec. 26. Recorded by E. P. Waterman.
29. Recorded by E. P. Waterman.
Jan. 16. Substitute this position for the one published in *A. J.* 668. An unfortunate mis-identification of the comparison star has just been noticed.
Feb. 20. Bright. Short tail.
Mar. 12. 9th mag. Nucleus. Parabolic. Tail pointing northwest.
15. Brighter than 9th mag. Nucleus.
25. The number of whole revolutions of the screw appears to have been read in the wrong direction from the graduation 40. The declination has received the correction $-21''.3$.
Mar. 30. Moon-light.
Apr. 24. Brighter than at the time of the last observation.
June 22. 10.5 mag.
30. 10.5 mag. Nucleus visible at times.
Aug. 26. 11th mag.
Aug. 31. Very faint. Nucleus visible at times.
Sept. 18. Visible, but too faint to measure.

☄ *c* 1914 (Campbell)

Sept. 27. Re-reduced with a new position of comparison star. In the previous reduction the position of the comparison star depended on a micrometer comparison with *β Sculptoris*.
29. Re-reduced with a new position of comparison star. Previous reduction depended on micrometer comparison of comparison star with *First Arg. Gen. Cat.* 31492.

☄ *a* 1915 (Mellish)

Mar. 12. 11th mag. Nucleus.
14. 10th mag. Nucleus.

☄ *a* 1915 (Mellish) — (*Continued.*)

Mar. 15. 9.2 mag. Nucleus.

30. Moon-light.

May 13. Nucleus and bright coma. Seeing good. Division of the head into two parts not visible.

14. Division of the nucleus into two parts distinctly visible at times. At Gr. M. T. $16^h\ 44^m$ the fainter portion was in position angle $291^\circ.1$ and at the distance $32''.1$ with respect to the main part.

16. At Gr. M. T. $16^h\ 35^m$, $p = 287^\circ.6$ $d = 33''.9$.

18. At Gr. M. T. $15^h\ 14^m$, $p = 291^\circ.4$ $d = 40''.8$.

June 23. Naked eye.

July 14. Tail fainter.

18. Brighter than July 14. Parabolic.

20. Wider parabolic than on July 18.

28. Moon-light and day-break. Tail very faint. Nucleus sharp.

Aug. 11. Tail easily visible. Parabolic. Nucleus.

16. 7¼ mag. Coma bright.

17. Seeing exceptionally good. Appears one full magnitude brighter than on Aug. 16. Parabolic. Suggestion of envelopes.

20. Tail weaker. Suggestion of envelopes.

Sept. 3. Tail very short. Wide parabola.

16. Brightness same as last observation. Parabolic with dark axis.

☄ *b* 1915 (Winnecke)

Oct. 1. 10th mag. Round. Nucleus visible at times.

7. 9.5 mag. About $40''$ in diameter. Nucleus a little out of center.

28. 9.3 mag.

29. Larger and more diffuse. Nucleus visible at times.

Nov. 11. Moon-light. Observation difficult.

☄ *c* 1915 (Taylor)

Dec. 6. 10th mag. Slightly elongated northwest. Probably nucleus. Declination has received correction 2 rev. north. (rev. = $24''.72$) *L. O. B.* 281. Eph. Corr. $+0''.3$ and $+3''.3$.

8. Eph. Corr. $+0''.7$ and $+3''.2$.

9. Eph. Corr. $+3''.4$ and $+1''.1$. Number of whole revolutions of screw supplied by Eph. Corr.

☄ *a* 1916 (Neujmin)

Mar. 2. 10.5 mag. Nucleus visible at times. Difficult to observe.

8. Nucleus visible at times.

8. Measure difficult owing to wide separation of wires and low altitude.

24. 10 to 10½ mag. Diameter $5'$. Central condensation.

25. Interrupted by clouds.

30. Difficult by transits.

31. Faint. Difficult by transits.

Apr. 6. 10½ to 11th mag. Diameter $5'$. Faint central condensation.

8. 10½ mag. No nucleus. The comparison star is *B.D.* -3°, 2757. This star has been accidentally omitted from the observing program. To avoid further delay, the incomplete reduction is published. The comparison star falls within the astrographic zone of the San Fernando Observatory, and its position would doubtless be furnished upon request.

22. 11th mag. Diameter larger. Measure difficult.

30. Measure difficult.

May 3. 10th mag. Diameter $1'$. Nucleus visible at times.

June 4. Measure difficult.

The publication of these observations has been unavoidably delayed awaiting meridian circle observations of the comparison stars (see *A. J.*, No. 731) and the corrections for the graduation errors of the new Repsold Meridian Circle which have only recently been determined. Hereafter southern comet observations can be reduced and published more promptly for recent additions to the zone catalogs have bridged some troublesome gaps. With the exception of the narrow belt, −20° to −22°, the southern declinations are covered by the following recent catalogs: *Second Argentine General*, Cordoba A, −22° to −27°, Cordoba B, −27° to −32°, (second proof) Cordoba C, −32° to −37°, (manuscript), *Perth Catalogs of Standard Astrographic Stars*, −31° to −41°, *Cape Catalog of Standard Astrographic Stars*, −40° to −52°, and *Bordeaux Catalog of Argelander Stars*, −15° to −20°. It is understood from the last report of the Algiers Observatory that the Algiers *A. G. Catalog*, −18° to −23°, is ready for publication, and it is expected that the La Plata extension of the *A. G. Catalog*, −52° to −62° is nearing completion.

Observatorio Nacional, Cordoba, Aug. 1917.

A CORRECTION

In *A. J.* No. 668, the observation of *f* 1913 (Delavan), 1914, Jan. 16 is in error, owing to a mis-identification of the comparison star. The corrected position is published in this number of *A. J.*

OBSERVATIONS OF THE NINTH SATELLITE OF *JUPITER*,

By SETH B. NICHOLSON.

The following positions of *Jupiter's* Ninth Satellite have been obtained from photographs taken with the 60-inch reflector. The plate measures were reduced by Turner's method using the rectilinear coördinates of the comparison stars instead of their right ascensions and declinations. The right ascensions and declinations of the satellite, referred to the epoch of the catalogue (1900.0), were then obtained from the published plate constants. The reductions from 1900.0 to 1917.0 are given in the column headed "Red. to 1917.0." The time given is the observed Greenwich Mean Time of mid-exposure, the exposure in each case being one hour. Star 118 on Plate 379 of the Paris *Astrographic Catalogue* was measured but omitted in the reduction because of a discrepancy of 0″.5 in declination, indicating a proper-motion of about −0″.02 in that coördinate.

Ninth Satellite

Gr. Mean Time 1917	α (1917.0)	δ (1917.0)	Red. to 1917.0 α	Red. to 1917.0 δ	Log pΔ α	Log pΔ δ	Stars
d h m	h m s	° ′ ″	s	″			
Oct. 12 21 19.0	4 33 47.74	+20 26 32.7	+60.10	+125.9	9.347*n*	0.364	*Paris Astro. Cat.*, Plate 379 Nos. 109, 110, 116, 120, 122, 124
Nov. 10 19 0.0	4 22 5.18	+20 11 35.9	+59.83	+141.9	9.396*n*	0.383	*Paris Astro. Cat.*, Plate 1274 Nos. 132, 134, 137, 139

Mt. Wilson Solar Observatory, January, 1918.

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Editor, Benjamin Boss, Albany, N. Y.; Associate Editors: E. E. Barnard, Ernest W. Brown, F. R. Moulton and R. S. Woodward
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APR 1
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NOTE ON SOME FORMULAS USED BY G. W. HILL IN HANSEN'S METHOD.

By R. T. A. INNES.

To the first order of the masses HANSEN's method requires

$$T = A a\frac{\partial\Omega}{\partial g} + B\, ar\frac{\partial\Omega}{\partial r}$$

(See HILL's *Jupiter* and *Saturn*, p. 72.)

The second order requires

$$B = r\frac{\partial T}{\partial r}$$

(See HILL's *Jupiter* and *Saturn*, p. 198.)

(This B is not the same B as used above, but no confusion results. Later, p. 341, he uses $\mathfrak{A}$ and $\mathfrak{B}$ for the first A and B.)

HILL and HANSEN both put this

$$B = V + X$$

in which

$$V = A\frac{\partial}{\partial g}\, ar\frac{\partial}{\partial r}\,\Omega + B\, ar\frac{\partial}{\partial r}\, r\frac{\partial}{\partial r}\,\Omega$$

and

$$X = Ma\frac{\partial\Omega}{\partial g} + N\, ar\frac{\partial\Omega}{\partial r}$$

(See HILL's *Jupiter* and *Saturn*, p. 211.)

In X, it is obvious that

$$M = r\frac{\partial A}{\partial r} \quad \text{or} \quad -\frac{2r\rho}{a^2\mathsf{C}^2\varphi}\,\mathsf{C}\,(f-\omega)$$

(See HILL's *Jupiter* and *Saturn*, p. 211.)

and

$$N = r\frac{\partial B}{\partial r} \quad \text{or} \quad -\frac{2\rho}{a\mathsf{C}^3\varphi}\,[\mathsf{S}f\mathsf{C}\omega - (\mathsf{C}f + e)\mathsf{S}\omega]$$

as indeed HILL shows on page 200.

In proceeding to the third order we require

$$r^2\frac{\partial^2 T}{\partial r^2} = r\frac{\partial B}{\partial r} = r\frac{\partial}{\partial r}\,(V + X)$$

In forming it, we note that

$$r\frac{\partial M}{\partial r} = M \qquad \text{and} \qquad r\frac{\partial N}{\partial r} = 0$$

HILL now gives (p. 341)

$$r^2\frac{\partial^2 T}{\partial r^2} = \mathfrak{A}\frac{\partial}{\partial g}\left[a_0\; r\frac{\partial}{\partial r}{}^2\,\Omega\right] + \mathfrak{B}a_0{}'\, r\frac{\partial}{\partial r}{}^3\,\Omega - B - X + 2Y$$

with a similar expression for $r_1{}^2\dfrac{\partial^2 T}{\partial r_1{}^2}$

which I cannot reproduce. Confining attention to hee former I find instead of $(-B - X)$ simply $M\dfrac{\partial}{\partial g}a\Omega$. I should be glad if some astronomer conversant with HANSEN's method will be so good as to verify HILL's formula of p. 341.

I find two other difficulties in HILL's theory to which attention may be drawn. In forming μ on page 66 HILL puts

$$\mu = \frac{m'}{1+m}\,\alpha\,\frac{a}{\mathrm{a}}$$

in which the a is the mean distance derived from

$$a^3 = f\,(1 + m)\,n^2$$

and a is the mean distance corrected for the constant effect of the planets. Should not the factor $\dfrac{a}{\mathrm{a}}$ be omitted or taken as unity? The basis of HANSEN's procedure is to adopt a mean ellipse and it seems to be quite justifiable to assume that a is furnished directly by observation and not by means of the above KEPLERIAN equation. This being so, it would only be necessary to put the constant in ν introduced by integration $= 0$. Practically it is of course better to find a through n, but I am not at all sure that HILL's distinction is necessary and if it is not then its adoption leads to slight error.

Lastly, in regard to the reduction to fixed plane which HILL considers in his Chapter XXVII; although the point is of practically no importance as the term in question amounts to only 0″.005 in five hundred years in the case of *Jupiter* and *Saturn*: it will be seen that HILL modified HANSEN's formula and puts (last line, p. 518), when terms of the fourth order are neglected

$$l = f + \pi + \Gamma - \tfrac{1}{2}s\frac{ds}{dv}$$

I doubt the legitimacy of the transform which introduces the $\frac{1}{2}s\frac{ds}{dv}$. It is got by considering $\mathsf{C}b$ = unity in

$$\mathsf{C}b\,\mathsf{S}\,(l - f - \pi - \Gamma) = -\tfrac{1}{2}s\frac{ds}{dv}$$

but

$$\mathsf{C}^2b = 1 - s^2 \qquad \text{because} \qquad \mathsf{S}b = s$$

therefore, rigorously

$$\mathsf{C}\,(l - f - \pi - \Gamma) = \frac{1 - \frac{1}{2}s^2}{\sqrt{1 - s^2}} = 1 + \tfrac{3}{8}s^4$$

or

$$l = f + \pi + \Gamma$$

if terms of the fourth order are neglected, the $-\frac{1}{2}s\frac{ds}{dv}$ adding nothing to the accuracy of the equation.

These queries are put forward with some diffidence.

Union Observatory, Johannesburg, 1917, November 9.

OBSERVATIONS OF COMET 1916 *b* (WOLF)

MADE WITH THE 26-INCH EQUATORIAL OF THE U. S. NAVAL OBSERVATORY.

[Communicated by Rear Admiral T. B. HOWARD, U. S. N., Superintendent.]

Date Wash. M. T.	*	Comp.	Δα	Δδ	App. α	App. δ	Log pΔ		Red. to App. Pl.	
							α	δ		
1917 h m s			m s	′ ″	h m s	° ′ ″			s	″
July 23 12 11 23	1	25 , 5	+2 24.02	+ 0 20.0	23 20 50.69	+23 39 19.8	9.555*n*	0.495	+3.59	+15.3*
30 11 51 4	2	30 , 6	−3 45.63	− 0 26.3	23 27 47.88	+22 32 0.7	9.551*n*	0.512	+3.74	+17.4*
Aug. 11 12 53 47	3	25 , 5	+1 28.93	+ 2 22.9	23 36 1.82	+19 36 5.8	9.229*n*	0.481	+4.00	+21.0*
20 12 38 54	4	25 , 5	−2 29.27	− 3 49.0	23 39 14.93	+16 38 7.5	9.122*n*	0.529	+4.15	+23.5*
22 12 12 12	5	30 , 6	+1 4.51	+ 1 19.5	23 39 39.51	+15 54 12.3	9.230*n*	0.548	+4.18	+24.0†
25 11 12 29	6	25 , 5	−0 56.67	+10 40.7	23 40 6.98	+14 46 4.2	9.411*n*	0.586	+4.22	+24.8*
Sept. 12 12 35 58	7	10 , 10	+0 21.36	+ 5 27.8	23 39 47.47	+ 7 11 31.6	8.660	0.663	+4.45	+28.5†
13 11 30 19	8	25 , 5	+1 54.41	− 0 47.8	23 39 41.87	+ 6 47 9.5	8.892*n*	0.668	+4.46	+28.6*
18 11 55 18	9	30 , 6	+2 35.50	− 3 6.3	23 39 9.72	+ 4 41 13.7	8.098	0.692	+4.47	+28.9†
22 11 55 14	10	30 , 6	+2 5.93	− 5 44.2	23 38 47.00	+ 3 4 46.0	8.649	0.710	+4.50	+29.2†
Oct. 3 9 17 28	11	25 , 5	−0 49.82	− 9 53.8	23 38 22.50	− 0 50 56.3	9.252*n*	0.748	+4.53	+29.4*
6 9 19 50	12	25 , 5	+2 10.26	+ 1 11.2	23 38 29.85	− 1 47 37.3	9.184*n*	0.756	+4.55	+29.4*
20 10 11 3	13	25 , 5	−2 51.29	+ 2 41.4	23 40 47.05	− 5 20 19.0	8.767	0.786	+4.53	+28.5*
22 11 31 19	14	15 , 9	−1 41.60	+ 3 56.2	23 41 22.74	− 5 44 10.5	9.341	0.783	+4.53	+28.4†
Nov. 5 10 57 39	15	23 , 5	−5 38.10	+ 5 55.4	23 47 12.46	− 7 42 32.9	9.393	0.794	+4.49	+27.2*
8 10 31 41	16	25 , 5	+4 12.10	− 6 47.8	23 48 49.72	− 7 58 17.9	9.342	0.798	+4.42	+26.8*
16 10 19 13	17	30 , 6	−6 43.03	+ 9 25.1	23 53 46.24	− 8 28 56.6	9.389	0.799	+4.40	+26.1†
17 8 47 46	17	25 , 5	−6 4.65	+ 7 1.3	23 54 24.62	− 8 31 20.8	8.899	0.809	+4.40	+26.0*
19 8 36 51	17	25 , 5	−4 11.52	+ 2 47.0	23 55 47.74	− 8 35 35.2	8.849	0.810	+4.39	+25.9*
Dec. 1 8 43 14	18	5 , 4	+0 13.34	− 2 7.1	0 5 4.80	− 8 42 9.4	9.196	0.807	+4.30	+24.9*
10 7 30 58	19	25 , 5	−1 34.91	+ 0 57.0	0 12 54.21	− 8 29 14.4	8.844	0.809	+4.22	+24.0*

Observers: * = H. E. BURTON; † = ERNEST CLARE BOWER.

Observations on Sept. 12 and Dec. 1 were made with driving clock running; all others, by transits.

Mean Places of Comparison Stars for 1917.0

*	α	δ	Authority	*	α	δ	Authority
	h m s	° ′ ″			h m s	° ′ ″	
1	23 18 23.08	+23 38 44.5	*A.G. Berlin B* 8946	11	23 39 7.79	− 0 41 31.9	*A.G. Nicolajew* 5882
2	23 31 29.77	+22 32 9.6	*A.G. Berlin B* 9031	12	23 36 15.04	− 1 49 17.9	*A.G. Straszburg* 8116
3	23 34 28.89	+19 33 21.9	*A.G. Berlin A* 9645	13	23 43 33.81	− 5 23 28.9	*A.G. Straszburg* 8141
4	23 41 40.05	+16 41 33.0	*A.G. Berlin A* 9683	14	23 43 2.81	− 5 18 35.1	*A.G. Straszburg* 8134
5	23 38 30.82	+15 52 28.8	*A.G. Berlin A* 9670	15	23 52 46.07	− 7 48 55.5	*A.G. Wien-Ottak.* 8433
6	23 40 59.43	+14 34 58.7	*A.G. Leipzig I* 9424	16	23 41 33.20	− 7 52 26.9	*A.G. Wien-Ottak.* 8409
7	23 39 21.66	+ 7 5 35.3	*A.G. Leipzig II* 11746	17	0 0 24.87	− 8 38 48.1	*A.G. Wien Ottak.* 8467
8	23 37 43.00	+ 6 47 28.7	*A.G. Leipzig II* 11738	18	0 4 47.16	− 8 40 27.2	*A.G. Wien-Ottak.* 16
9	23 36 29.75	+ 4 43 51.1	*A.G. Albany* 8135	19	0 14 24.90	− 8 30 35.4	*A.G. Wien-Ottak.* 49
10	23 36 36.57	+ 3 10 1.0	*A.G. Albany* 8136				

NOTES

Date	Seeing
July 23.	Good.
30.	Fair. Comet faint. Moonlight.
Aug. 11.	Poor.
20.	Good. Comet faint at times on account of haze.
22.	Fair. Easily visible in 5-inch finder.
25.	Poor.
Sept. 12.	Poor. Easily visible in 5-inch finder.
13.	Good.
18.	Fair. Comet diffuse, diameter of head about 4″. Easily visible in 5-inch finder.
22.	Fair. Comet diffuse. Easily visible in 5-inch finder. Some haze. Poor observation.
Oct. 3.	Poor. Comet faint. Moonlight.
6.	Poor. Barely visible in 5-inch finder.
20.	Poor. Barely visible in 5-inch finder.
22.	Fair. Barely visible in 5-inch finder. Poor observation.
Nov. 5.	Fair. Barely visible in 5-inch finder.
8.	Poor. Barely visible in 5-inch finder.
16.	Fair. Poor observation.
17.	Poor.
19.	Fair.
Dec. 1.	Very poor. Comet very faint. Observation unsatisfactory.
10.	Fair. Comet very faint. Poor observation.

OBSERVATIONS OF MINOR PLANETS.

MADE WITH THE 12-INCH EQUATORIAL OF THE U. S. NAVAL OBSERVATORY,

By WILLIAM A. CONRAD.

[Communicated by Rear Admiral T. B. Howard, U. S. N., Superintendent.]

Date	Wash. M.T.	*	Comp.	Δα	Δδ	App. α	App. δ	Log pΔ		Red. to App. Pl.	
								α	δ	α	δ
					(15) *Eunomia*						
1916	h m s			m s	′ ″	h m s	° ′ ″			s	″
Sept. 9	13 28 46	1	50,10	−3 0.46	+ 5 8.5	22 42 23.54	+10 7 40.8	9.373	0.641	+4.24	+25.7
11	12 46 34	2	57,11	−4 13.75	− 1 15.0	22 40 32.41	+10 4 30.8	9.248	0.634	+4.24	+25.9
17	9 3 26	3	29, 6	+3 44.00	− 3 0.6	22 35 16.17	+ 9 50 58.8	9.313*n*	0.640	+4.21	+26.1
19	9 37 2	3	30, 6	+2 0.89	− 8 58.5	22 33 33.07	+ 9 45 1.2	9.092*n*	0.633	+4.22	+26.4
27	10 59 9	4	34, 7	−2 27.25	+16 29.4	22 27 32.65	+ 9 16 36.7	9.064	0.639	+4.18	+26.8
Oct. 6	9 2 37	5	29, 6	−2 8.24	− 1 53.4	22 22 52.25	+ 8 40 33.6	8.575*n*	0.644	+4.14	+27.3

Date	Wash. M.T.	*	Comp.	Δα	Δδ	App. α	App. δ	Log pΔ		Red. to App. Pl.	
								α	δ	α	δ
						(11) *Parthenope*					
1916	h m s			m s	′ ″	h m s	° ′ ″			s	″
Sept. 17	12 49 27	6	35, 7	−8 4.57	+ 0 9.6	22 47 10.33	−13 30 41.5	9.335	0.830	+4.56	+25.4
19	11 56 2	7	29, 6	−2 41.47	− 8 48.6	22 45 46.35	−13 41 8.3	9.121	0.838	+4.57	+25.0
20	11 0 35	8	10,10	−0 1.45	− 2 38.5	22 45 6.87	−13 45 56.9	8.467	0.843	+4.58	+24.7*
20	11 37 50	8	5, 5	−0 2.47	− 2 47.1	22 45 5.85	−13 46 5.5	9.022	0.841	+4.58	+24.7†
						(13) *Egeria*					
Oct. 6	12 0 8	9	50,10	+1 15.64	+ 0 16.9	1 19 41.42	− 5 21 46.5	8.544*n*	0.786	+4.51	+29.6
10	9 54 46	10	30, 6	+3 35.45	− 1 6.0	1 15 33.17	− 5 24 14.5	9.372*n*	0.780	+4.53	+29.4
						(22) *Kalliope*					
Oct. 10	12 19 5	11	30, 6	+6 38.42	+ 5 8.0	1 18 17.85	−10 8 15.2	8.577	0.821	+4.53	+29.2
27	13 38 26	12	50,10	−0 11.98	+ 5 34.9	1 3 25.11	−10 8 3.9	9.517	0.797	+4.58	+27.7
						(8) *Flora*					
1917											
Mar. 9	10 4 28	13	25, 4	−4 4.00	− 6 45.1	9 32 6.44	+21 17 15.2	8.603*n*	0.422	+3.07	−11.2
						(1) *Ceres*					
Mar. 19	14 18 2	14	25, 5	+5 54.01	+ 9 5.3	11 19 34.99	+22 46 50.8	9.520	0.490	+3.17	−16.3
24	9 20 56	14	25, 5	+2 4.04	+19 39.1	11 15 45.00	+22 57 25.2	9.349*n*	0.427	+3.15	−15.7
25	8 56 49	14	25, 5	+1 19.45	+21 4.3	11 15 0.41	+22 58 50.5	9.415	0.444	+3.15	−15.6
						(5) *Astræa*					
Mar. 24	11 7 49	15	30, 6	−0 35.11	+ 4 9.4	13 2 33.39	+ 1 5 38.9	9.312*n*	0.731	+2.92	−19.7
25	9 50 12	15	24, 5	−1 19.18	+11 28.8	13 1 47.33	+ 1 12 58.3	9.514*n*	0.732	+2.93	−19.7
						(7) *Iris*					
July 23	11 41 16	16	30, 6	+3 2.11	−10 49.5	19 59 33.67	−14 20 48.1	8.425*n*	0.846	+4.47	+11.8
29	10 50 2	17	30, 6	−0 26.03	+ 5 11.2	19 53 16.45	−14 27 10.3	8.848*n*	0.846	+4.52	+11.9
Aug. 13	11 43 8	18	25, 5	−1 23.16	− 0 7.2	19 38 59.36	−14 47 50.9	9.268	0.840	+4.57	+11.1
						(3) *Juno*					
July 23	14 33 41	19	30, 6	+3 28.22	− 1 46.1	20 25 12.98	− 4 9 42.5	9.404	0.771	+1.22	+13.8
29	11 37 36	20	30, 6	−0 38.77	+ 2 55.5	20 20 7.44	− 4 42 16.8	8.432*n*	0.781	+4.28	+14.5
Aug. 13	12 25 12	21	25, 5	+1 19.20	− 1 22.6	20 7 28.05	− 6 25 38.6	9.312	0.789	+4.40	+14.7
						(4) *Vesta*					
Aug. 25	15 36 45	22	50,10	−2 41.86	+ 0 24.5	0 51 32.33	− 5 45 7.8	9.063	0.788	+3.99	+28.4
Sept. 17	10 5 28	23	25, 5	+2 31.91	+ 2 46.4	0 40 15.00	− 8 29 23.2	9.492*n*	0.792	+4.44	+29.8
Oct. 6	13 4 16	24	10,10	−0 8.76	− 6 51.1	0 22 49.85	−10 26 16.0	9.304	0.815	+4.62	+29.2*
15	11 32 33	38	25, 5	−1 52.89	+10 22.9	0 15 20.06	−10 57 49.5	9.034	0.824	+4.61	+28.4
						(33) *Polyhymnia*					
Sept. 17	11 16 9	25	30, 6	+1 39.79	+4 40.0	0 39 50.85	+ 3 47 54.8	9.277*n*	0.705	+1.45	+28.8
18	10 50 30	25	30, 6	+1 1.50	+ 2 19.1	0 39 12.57	+ 3 45 31.0	9.356*n*	0.707	+1.46	+28.9
Oct. 6	10 1 10	26	30, 6	−0 5.58	+ 5 40.4	0 26 14.30	+ 2 54 41.0	9.199*n*	0.713	+4.61	+30.0
15	12 13 26	27	24, 5	+0 54.62	+14 42.2	0 20 22.01	+ 2 32 11.0	9.242	0.717	+4.60	+30.0

Date	Wash. M.T.	∗	Comp.	$\Delta\alpha$	$\Delta\delta$	App. α	App. δ	Log $p\Delta$		Red. to App. Pl.	
								α	δ	α	δ
(88) *Thisbe*											
1917	h m s			m s	′ ″	h m s	° ′ ″		s	″	
Sept. 18	9 58 33	28	30, 6	−1 12.69	+ 4 30.2	23 10 58.73	+ 4 7 6.7	9.208*n*	0.701	+4.45	+28.5
19	11 16 32	28	30, 5	−2 2.36	− 0 52.5	23 10 9.08	+ 4 1 44.4	6.840	0.699	+4.47	+28.9
(19) *Fortuna*											
Sept. 19	10 1 35	29	24, 5	+2 48.00	+ 8 57.6	23 45 12.22	+ 0 13 39.1	9.324*n*	0.738	+4.49	+29.0
Oct. 11	10 42 15	30	24, 5	−1 1.84	−15 48.6	23 28 55.66	− 1 57 41.5	8.829	0.758	+4.53	+29.2
15	10 59 45	31	25, 5	+1 43.23	− 1 13.1	23 26 59.03	− 2 15 37.1	9.134	0.760	+4.48	+28.8
(49) *Pales*											
Oct. 6	11 3 18	32	30, 6	−1 5.03	− 0 43.3	0 44 5.73	+10 36 35.4	8.905*n*	0.619	+4.67	+29.7
15	13 4 5	33	29, 6	+1 30.05	+ 3 23.6	0 37 19.17	+ 9 52 42.5	9.377	0.643	+4.66	+30.4
17	10 39 29	33	30, 6	+0 10.23	− 6 4.4	0 35 59.36	+ 9 43 14.5	8.394*n*	0.630	+4.67	+30.4
(29) *Amphitrite*											
Oct. 6	12 8 15	34	25, 5	+1 58.65	−11 23.1	1 50 52.80	+16 28 33.4	8.934*n*	0.526	+4.82	+26.5
Nov. 17	10 22 40	35	25, 5	−3 9.98	−12 29.9	1 14 27.04	+14 32 31.6	9.048	0.562	+4.89	+30.3
(135) *Hertha*											
Oct. 17	11 18 49	36	30, 6	−0 29.91	− 3 28.3	1 24 36.22	+11 54 37.1	8.639*n*	0.599	+4.80	+28.8

*$\Delta\alpha \cos\delta$ and $\Delta\delta$ measured with clock running.

†Position angle and distance measured.

Mean Places of Comparison Stars for the Beginning of the Year

∗	α	δ	Authority	∗	α	δ	Authority
	h m s	° ′ ″			h m s	° ′ ″	
1	22 45 19.76	+10 2 6.6	*A.G. Leipzig II* 11415	20	20 20 41.93	− 4 45 26.8	*A.G. Straszburg* 7050
2	22 44 41.92	+10 5 19.9	*A.G. Leipzig II* 11409	21	20 6 4.45	− 6 24 30.7	*A.G. Wien-Ottak.* 7101
3	22 31 27.96	+ 9 53 33.3	*A.G. Leipzig II* 11316	22	0 57 10.20	− 5 46 0.7	*A.G. Straszburg* 226
4	22 29 55.72	+ 8 59 40.5	*A.G. Leipzig II* 11312	23	0 37 38.65	− 8 32 39.4	*A.G. Wien-Ottak.* 139
5	22 24 56.35	+ 8 41 59.7	*A.G. Leipzig II* 11279	24	0 22 53.99	−10 19 53.8	*A.G. Cam., U.S.* 78
6	22 55 10.34	−13 31 16.5	Boss 5923	25	0 38 6.61	+ 3 42 46.0	*A.G. Albany* 164
7	22 48 23.25	−13 32 44.7	*A.G. Cam., U.S.* 8044	26	0 26 15.27	+ 2 48 30.6	*A.G. Albany* 90
8	22 45 3.74	−13 43 43.1	*A.G. Washington* 8474	27	0 19 22.79	+ 2 16 58.8	*A.G. Albany* 67
9	1 18 21.27	− 5 22 33.0	*A.G. Straszburg* 312	28	23 12 6.97	+ 4 2 8.0	*A.G. Albany* 8030
10	1 11 53.49	− 5 23 37.9	*A.G. Straszburg* 285	29	23 42 19.73	+ 0 4 12.5	*A.G. Nicolajew* 5891
11	1 11 34.90	−10 13 52.4	*A.G. Cam., U.S.* 253	30	23 29 52.97	− 1 42 22.1	*A.G. Nicolajew* 5850
12	1 3 32.51	−10 14 6.5	*A.G. Cam., U.S.* 226	31	23 25 11.32	− 2 14 52.8	*A.G. Straszburg* 8067
13	9 36 7.37	+21 24 11.5	*A.G. Berlin B* 3818	32	0 45 6.09	+10 36 19.0	*B.D.* + 10° 97 micrometer comparison on Nov. 17 with Star 37.
14	11 13 37.81	+22 38 1.8	*A.G. Berlin B* 4232	33	0 35 44.46	+ 9 48 48.5	*A.G. Leipzig II* 215
15	13 3 5.58	+ 1 1 49.2	*A.G. Albany* 4644	34	1 48 49.33	+16 39 30.0	*A.G. Berlin A* 539
16	19 56 27.09	−14 10 10.4	*A.G. Washington* 7516	35	1 17 32.13	+14 44 31.2	*A.G. Leipzig I* 383
17	19 53 37.96	−14 32 33.4	*A.G. Washington* 7505	36	1 25 1.33	+11 57 36.6	*A.G. Leipzig I* 422
18	19 40 17.95	−14 47 54.8	*A.G. Washington* 7424	37	0 46 55.63	+10 34 1.0	*A.G. Leipzig II* 229
19	20 21 40.54	− 4 8 10.2	*A.G. Straszburg* 7055	38	0 17 8.34	−11 8 40.8	*A.G. Cam., U.S.* 56

MEAN PLACES OF COMPARISON STARS FOR THE BEGINNING OF THE YEAR,

DETERMINED FROM OBSERVATIONS WITH THE NEW REPSOLD MERIDIAN CIRCLE, CORDOBA, TO ACCOMPANY THE ARTICLE "OBSERVATIONS OF ASTEROIDS AND COMETS," *A.J.* 730,

BY A. E. GLANCY.

No.	Designation	Mag.	Year	α	δ	No. Obs.	Epoch 1900+
1	*B.D.* − 2°, 186	9.7	14	2 42 46.67	− 2 03 21.9	6	15.87
2	. . . .	10	15	2 54 46.24	− 6 15 46.4	4	16.41
3	*B.D.* − 6°, 578	9.5	13	2 54 53.77	− 6 12 35.8	5	16.19
4	*B.D.* − 6°, 582	9.1	13	2 55 39.62	− 6 28 44.7	6	16.51
5	*A.G. Wien* 696	9.0	13	3 00 05.92	− 7 12 01.8	7	16.07
6	*C.D.* −57°, 1107	9.1	15	5 09 44.39	−57 17 19.3	6	16.31
7	*C.D.* −56°, 1157	9.5	15	5 15 16.68	−56 14 05.9	6	16.32
8	*C.D.* −51°, 1539	8.0	15	5 31 18.88	−51 41 56.6	6	16.31
9	*C.D.* −50°, 1864	6.5	15	5 36 14.14	−50 41 18.1	6	16.31
10	*C.D.* −48°, 1972	8.9	15	5 44 09.78	−48 00 14.0	6	16.32
11	*C.D.* −46°, 2024	8.4	15	5 46 33.19	−46 20 28.7	6	16.32
12	*C.D.* −45°, 2218	9.0	15	5 51 20.57	−45 42 25.1	6	14.32
13	*C.D.* −43°, 2184	9.1	15	5 57 09.75	−43 39 16.8	6	16.31
14	*C.D.* −39°, 2354	8.0	15	6 01 20.59	−39 49 49.7	6	16.31
15	*C.D.* −37°, 2642	8.9	15	6 07 21 54	−37 50 01.1	6	16.31
16	*C.D.* −36°, 2726	9.0	15	6 10 19.28	−36 16 12.9	6	16.31
17	*C.D.* −36°, 2727	9.0	15	6 10 20.89	−36 42 32.3	4	16.02
18	*C.D.* −33°, 2872	8.3	15	6 15 02.57	−33 16 18.1	6	16.31
19	*C.D.* −32°, 2950	8.7	15	6 17 21.92	−32 33 47.3	6	16.31
20	*C.D.* −28°, 3015	8.4	15	6 23 55.00	−28 24 44.8	4	16.10
21	*B.D.* −20°, 1404	8.3	15	6 24 59.64	−20 08 32.3	4	16.16
22	*B.D.* −19°, 1459	8.8	15	6 25 11.84	−19 59 22.6	4	16.18
23	*C.D.* −28°, 3043	8.5	15	6 25 22.00	−28 10 55.3	4	16.37
24	*C.D.* −25°, 3294	9.1	15	6 26 44.36	−25 53 56.3	5	16.15
25	*C.D.* −26°, 3079	8.3	15	6 27 18.72	−26 53 59.3	4	16.16
26	*C.D.* −25°, 3305	8.9	15	6 27 27.88	−25 22 15.8	6	16.16
27	*C.D.* −26°, 3084	9.1	15	6 27 42.40	−26 45 12.2	5	16.12
28	*C.D.* −22°, 3203	8.5	15	6 29 35.67	−22 32 41.0	4	16.09
29	*B.D.* − 8°, 1606	9.7	14	6 50 10.94	− 8 55 40.1	4	15.63
30	*B.D.* + 9°, 2120	9.4	16	9 01 59.73	+ 9 23 23.6	2	16.19
31	*B.D.* + 2°, 2182	9.3	16	9 16 30.60	+ 1 47 28.3	4	16.71
32	*B.D.* + 1°, 2287	9.5	16	9 17 14.08	+ 1 25 05.9	4	16.94
33	*B.D.* − 0°, 2200	9.2	16	9 23 54.57	− 0 40 02.2	4	16.71
34	. . . .	10	14	13 20 00.26	−27 33 04.0	4 , 5	16.34 , 16.70
35	*C.D.* −27°, 9226	9.1	14	13 21 49.52	−27 36 54.6	4 , 5	16.34 , 16.70
36	*C.D.* −52°, 6331	10¼	15	14 45 44.58	−52 17 25.9	4	16.16
37	*C.D.* −51°, 8534	9.2	15	14 46 39.51	−51 55 36.9	4	16.35
38	*C.D.* −51°, 8553	9.7	15	14 48 05.47	−51 35 10.6	4 , 5	16.35 , 16.71
39	*C.D.* −52°, 6358	8.2	15	14 48 09.94	−52 51 01.8	4	15.98
40	*C.D.* −51°, 8634	6.7	15	14 53 19.21	−51 14 08.8	4 , 5	16.35 , 16.71
41	*C.D.* −53°, 5780	9.4	15	14 53 32.81	−53 39 21.6	5	16.06
42	*C.D.* −53°, 5794	9.0	15	14 54 26.52	−53 13 36.4	4 , 5	16.15 , 16.54
43	*C.D.* −53°, 5815	10	15	14 56 12.39	−53 52 44.6	6	16.18
44	*C.D.* −51°, 8708	9.3	15	14 58 21.24	−51 10 19.0	4 , 5	16.35 , 16.71
45	*C.D.* −54°, 6037	9.2	15	15 01 26.99	−54 13 20.6	4	15.94
46	*C.D.* −51°, 8758	9.9	15	15 01 11.86	−51 12 00.0	4	16.13

No.	Designation	Mag.	Year	α	δ	No. Obs.	Epoch 1900+
47	*C.D.* −51°, 8763	9.2	15	15 01 57.33	−51 10 55.0	6 , 7	16.39 , 16.64
48	*C.D.* −54°, 6070	9.2	15	15 05 09.54	−54 24 04.8	4	15.71
49	*C.D.* −54°, 6136	8.4	15	15 12 24.97	−54 52 27.1	2	17.57
50	*C.D.* −55°, 6137	8.6	15	15 12 50.88	−55 13 04.1	6	15.64
51	*C.D.* −55°, 6448	9.4	15	15 53 33.63	−55 19 06.9	4	15.72
52	*C.D.* −55°, 6476	8.3	15	15 54 20.37	−55 23 25.6	5	16.02
53	*C.D.* −55°, 6514	9.8	15	15 58 00.93	−55 11 25.5	5	15.48
54	*C.D.* −30°, 13134	8.3	15	16 20 32.16	−30 14 58.3	4	16.37
55	*C.D.* −30°, 13229	8.9	15	16 27 10.45	−30 52 26.7	5	16.39
56	*C.D.* −53°, 6777	8.4	15	16 29 39.52	−54 02 29.9	4	15.49
57	*C.D.* −53°, 6829	7.8	15	16 33 48.60	−53 58 09.1	5	15.48
58	*C.D.* −53°, 6858	8.5	15	16 36 19.74	−53 39 56.4	5	15.48
59	*C.D.* −53°, 6900	8.3	15	16 40 53.85	−53 29 58.9	5	15.48
60	*C.D.* −53°, 6940	9.2	15	16 45 55.68	−53 08 35.1	4	15.49
61	*C.D.* −52°, 7860	9.0	15	16 52 00.49	−52 35 49.7	4	15.49
62	*C.D.* −33°, 11723	9.5	15	17 00 45.34	−33 44 10.7	6	16.43
63	*B.D.* −18°, 4508	8.8	15	17 17 30.23	−19 01 14.5	5	15.48
64	*B.D.* + 2°, 3302	9.3	15	17 18 03.55	+ 2 25 15.2	4	16.41
65	*C.D.* −49°, 11429	8.5	15	17 19 20.94	−49 10 33.4	5	15.48
66	*C.D.* −48°, 11804	9.3	15	17 26 11.17	−48 19 26.5	2	17.61
67	*C.D.* −48°, 11807	9.3	15	17 26 21.70	−48 26 17.7	4	15.49
68	*A.G. Alb.* 5901	9.0	15	17 40 57.43	+ 0 51 27.7	4	16.45
69	*A.G. Nic.* 4414	8.8	15	17 44 0.84	+ 0 35 20.1	4	16.44
70	*C.D.* −27°, 11991	7.0	15	17 45 01.98	−27 02 06.6	4	15.75
71	*A.G. Nic.* 4420	8.8	15	17 45 03.44	+ 0 27 19.2	4	16.44
72	*C.D.* −27°, 12009	8.6	15	17 45 47.66	−27 22 12.6	4	15.74
73	*A.G. Nic.* 4446	9.2	15	17 50 43.32	− 0 12 45.8	4	16.44
74	*C.D.* −39°, 12027	7.5	15	17 50 54.47	−39 55 11.8	4	16.00
75	*C.D.* −34°, 12289	8.5	15	17 51 01.38	−34 31 06.3	6	16.06
76	*C.D.* −39°, 12042	9.0	15	17 51 29.90	−39 49 50.2	4	16.50
77	*C.D.* −37°, 12036	8.0	15	17 52 46.48	−37 57 53.4	5	16.06
78	*C.D.* −36°, 12066	9.0	15	17 53 32.89	−36 05 17.9	4	15.74
79	*C.D.* −33°, 12700	7.4	15	17 54 20.11	−33 24 07.8	4	16.19
80	*C.D.* −35°, 12142	8.5	15	17 54 28.73	−35 38 36.8	4	15.74
81	*A.G. Nic.* 4500	8.5	15	18 04 08.61	− 1 29 47.0	4	16.44
82	*C.D.* −38°, 13358	8.7	15	19 04 54.27	−38 34 17.5	4	16.51
83	*B.D.* −21°, 5292	7.0	15	19 07 23.30	−21 48 00.4	4	15.62
84	*C.D.* −23°, 15181	8.7	15	19 08 59.37	−23 12 42.1	4	15.62
85	*C.D.* −38°, 13404	8.0	15	19 12 25.16	−38 32 07.0	4	16.51
86	*C.D.* −38°, 13426	8.7	15	19 15 41.11	−38 37 26.4	4	16.51
87	*C.D.* −25°, 13969	9.3	15	19 16 43.00	−25 53 03.3	5	15.62
88	*C.D.* −27°, 13917	9.0	15	19 19 16.92	−27 10 41.8	4	15.62
89	*C.D.* −31°, 16750	7.0	15	19 24 16.06	−30 58 01.5	5	15.62
90	*C.D.* −38°, 13643	9.3	15	19 38 12.68	−38 26 06.2	4	16.51
91	*C.D.* −38°, 13832	7.3	15	19 58 24.13	−38 06 22.4	4	16.51
92	*C.D.* −37°, 13746	9.0	15	20 21 42.91	−37 20 43.7	4	16.58
93	*C.P.D.* −62°, 6214	9.6	15	21 11 28.15	−62 32 49.8	4	15.75
94	*B.D.* −11° 5782	9.1	14	22 08 52.88	−11 10 47.7	6	15.68
95	*B.D.* −12°, 6226	9.9	14	22 12 09.40	−12 31 36.5	8 , 7	15.60
96	*B.D.* −16°, 6082	7.8	14	22 21 06.76	−15 47 38.6	4	16.19
97	*B.D.* −18°, 6129	8.0	14	22 23 10.74	−17 42 34.5	4	16.19

No.	Designation	Mag.	Year	α	δ	No. Obs.	Epoch 1900+
98	*B.D.* −19°, 6328	8.0	14	22 39 54.38	−19 32 26.2	5	15.90
99	*C.D.* −36°, 15627	9.3	13	22 50 56.36	−36 37 50.2	5	15.73
100	*C.D.* −26°, 16385	9.3	14	22 52 01.21	−26 42 44.5	5	15.90
101	*C.D.* −37°, 15119	8.6	13	23 05 48.96	−37 11 10.7	6	15.57
102	*C.D.* −32°, 17434	7.5	14	23 08 19.20	−32 47 02.3	4	15.24
103	......	10	14	23 10 16.34	−32 11 57.5	5	16.28
104	*C.P.D.* −72°, 2757	8.0	15	23 16 15.06	−72 02 24.5	4	15.75
105	*C.D.* −35°, 15782	9.0	14	23 20 16.40	−35 17 43.6	1	15.24
106	*C.D.* −38°, 15567	8.5	14	23 33 03.75	−38 08 40.5	5	15.15

Most of the observations and their reductions were made by MR. C. HAWKINS, to whom I am indebted for so much work kindly inserted in the regular observing program. MR. L. GUERIN has also obliged me at various times.

All reductions have been checked by the writer. The probable error of a single observation in R. A. is $\pm 0^s.037 \sec \delta$, in Dec. $\pm 0''.43$. In every case but three there are at least two observations clamp west and two observations clamp east. The declinations have been corrected for the graduation errors of the circles. A mean correction for magnitude has been applied to the right ascensions, in amount.

$$-0^s.007 \text{ (mag. } -4.0)$$

thus reducing the fainter stars to the same basis as the fundamental time stars. The authority for the magnitude is the same as for the designation of the star.

The meridian circle observations made earlier than Jan. 1, 1916, refer to the fundamental system of Boss; the later ones are based on the American Ephemeris. Since many of these stars were observed both before and after this date, no more definite statement can be made without going into the details of observation.

Owing to several mis-identifications and the addition of bright auxiliary stars to be used in case that certain faint stars should prove difficult to observe, this list contains a few unused positions. They are retained here because it seems the most convenient place for publication.

For some of these stars there are catalog positions, but they have been re-observed to bring the epoch of observation approximately to the epoch of the micrometer observations and to refer all observations of ☄ *f* 1913 (DELAVAN) and ☄ *a* 1915 (MELLISH) to the same system. In February, 1916, a list of the comparison stars for ☄ *f* 1913 (DELAVAN) was forwarded to the La Plata Observatory at the request of MR. G. VANBIESBROECK, who had arranged with PROFESSOR HUSSEY for the observation of all comparison stars for this comet. So for these stars there should be available later the additional determinations by the La Plata Observatory.

Observatorio Nacional, Cordoba, Aug., 1917.

EDITORIAL NOTE.

For the convenience of observers of the total solar eclipse of June 8, 1918, a number of the *Astronomical Journal* will be published just prior to the eclipse. It is intended to publish in that number any late news which may be of immediate importance to observers. Such news will be gladly received by us, and will be promptly transmitted to any observing station which has previously registered its address with us.

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OBSERVATIONS,

By A. ESTELLE GLANCY.

Comet Mellish (*a* 1917)

Photographic observations made with the south dome photographic telescope of 64 cm. focal length and aperture reduced to 10 cm.

Obs.	Date 1917	Gr. M.T. Mid-Exp.	Exp.	Pos. Angle of Tail
		h m	m	°
W	Apr. 19	21 41	6	234
G	20	21 32	19	231
G	21	21 28	15	236
G	22	21 27	17	238
G	29	21 21	27	234

Observers: W = Mr. R. Winter; G = Miss Glancy.

All photographs were taken in the morning twilight very close to the horizon.

General characteristics of tail: symmetrical, fading gradually with increasing distance from the head, without detail, slightly curved.

Description of Plates

Apr. 19.	Tail 2°.5, slightly concave on the northwest side, head round and bright.
20.	Tail 5°, slightly curved.
21.	About the same as Apr. 20, but image weaker.
22.	Same as Apr. 21.
29.	Weaker. Tail straight. Ejection from the head makes a wider angle. Main tail is on one side of the fan.

Comet Mellish (*a* 1917)

Photographic Positions Deduced from Astrographic Plates.

Plate No.	Date	Gr. M.T.	Astrographic 1917.0 α	Astrographic 1917.0 δ	No. Images	Measure	Remarks
		h m s	h m s	° ′ ″			
6476	Apr. 19	21 49 . .	0 43 07.42	− 1 52 04.4	2	G	Comp. stars very faint.
6481	21	21 47 38	0 46 57.87	− 3 26 45.4	2	O	Comp. stars very faint.
6482	22	21 38 20	0 49 03.14	− 4 06 36.0	2	O	
6483	24	21 40 52	0 53 28.14	− 5 15 40.4	2	O	
6484	29	21 30 56.	1 04 48.73	− 7 22 32.1	2	O	
6485	30	21 31 36	1 07 03.33	− 7 42 38.2	1	O	
6486	May 7	21 27 27	1 22 03.77	− 9 33 39.6	1	O	Images poor.
6488	10	21 53 35	1 28 08.44	−10 11 09.4	2	S	
6490	12	22 00 19	1 31 56.32	−10 33 57.8	2	S	☄ extremely faint.
6492	14	21 44 02	1 35 37.92	−10 55 20.1	2	S	☄ extremely faint.
6493	14	22 02 10	1 35 39.42	−10 55 29.4	1	S	☄ faint.
6497	17	21 42 19	1 41 00.17	−11 25 51.7	1	S	Images poor.
6498	20	21 37 54	1 46 05.79	−11 55 06.1	1	S	☄ faint.
6499	23	21 17 34	1 50 55.25	−12 23 23.2	1	S	☄ near edge of plate.
6500	25	21 37 53	1 54 00.67	−12 41 57.5	1	S	
6501	29	21 38 00	1 59 51.88	−13 19 06.2	1	S	☄ very faint.
6502	June 2	21 48 22	2 05 19.56	−13 56 52.2	1	S	☄ very faint.

All plates were taken by Mr. R. Winter, with the exception of the first, which was taken by Mr. F. Symonds. The measures were made by Miss Glancy, Miss E. C. Ogilvie and Miss H. G. Symonds.

The plate constants depend upon four *A. G.* stars. All reductions were made by Miss Glancy.

The exposures were made under difficulty, being taken at low altitude in the morning twilight. The first exposure was two minutes. The succeeding exposures were lengthened as opportunity permitted, until the last two were between three quarters of an hour and an hour.

Micrometer Observations,

Made with the 12-Inch Equatorial.

Date	Gr. M. T.	*	Comp. α	Comp. δ	$\Delta\alpha$	$\Delta\delta$	App. α	App. δ	Log $p\Delta$ α	Log $p\Delta$ δ	Red. to App. Pl. α	Red. to App. Pl. δ
					Comet Mellish (*a* 1917)							
1917	h m s				m s	″	h m s	° ′ ″			s	″
Apr. 20	21 56 05	1	6*t*,	6	+1 36.62	+4 08.5	0 41 59.94	− 2 42 16.8	9.690*n*	0.651*n*	+0.68	+ 5.9
24	21 47 54	2	8*t*,	8	−0 34.73	+3 47.5	0 53 28.86	− 5 15 40.6	9.692*n*	0.643*n*	+0.72	+ 6.7
29	21 50 49	3	7*t*,	7	−0 59.83	+7 34.6	1 04 51.58	− 7 22 25.5	9.688*n*	0.631*n*	+0.77	+ 7.9
May 5	21 49 06	4	10*t*,	10	+0 27.84	−2 40.9	1 17 58.24	− 9 06 05.9	9.686*n*	0.618*n*	+0.79	+ 8.8
9	21 21 18	5	12*t*,	11	+0 41.30	−2 17.5	1 26 06.28	− 9 57 13.1	9.697*n*	0.625*n*	+0.85	+ 9.6
14	21 25 09	6	11*t*,	11	−0 37.28	−3 25.5	1 35 38.08	−10 55 04.5	9.691*n*	0.612*n*	+0.90	+10.6
17	21 55 47	7	11*t*,	11	+1 16.25	+3 43.1	1 41 01.91	−11 25 46.0	9.666*n*	0.584*n*	+0.93	+11.2
18	21 38 48	8	11*t*,	11	+0 58.21	+8 41.5	1 42 43.74	−11 35 23.5	9.678*n*	0.593*n*	+0.93	+11.3
25	21 18 06	9	11*t*,	11	+1 09.25	−4 13.8	1 54 03.15	−12 11 45.4	9.658*n*	0.566*n*	+1.04	+12.8
June 2	21 28 18	10	12*t*,	11	−0 41.73	−5 48.0	2 05 20.82	−13 56 32.4	9.660*n*	0.554*n*	+1.12	+13.9
19	22 01 41	11	7*t*,	7	−2 12.64	−4 20.9	2 24 11.98	−16 53 29.5	9.543*n*	0.437*n*	+1.42	+18.1
21	21 50 28	12	13*t*,	13	−0 15.47	+3 49.3	2 25 57.41	−17 16 39.6	9.554*n*	0.435*n*	+1.47	+18.8
22	21 51 44	13	11*t*,	11	+1 23.18	+8 45.5	2 26 47.86	−17 28 32.6	9.545*n*	0.426*n*	+1.50	+19.2
24	21 50 58	14	12*t*,	12	−1 10.96	+4 25.9	2 28 24.34	−17 52 40.0	9.535*n*	0.413*n*	+1.52	+19.5
					Comet Schaumasse (*b* 1917)							
Apr. 30	21 27 39	15	11*t*,	11	−0 27.13	+3 19.3	23 10 42.14	+13 29 26.4	9.604*n*	0.743*n*	+1.12	+ 2.3
					(10) *Hygiea*							
Aug. 23	12 33 42	16	13*t*,	13	−0 45.85	−7 35.4	20 02 18.45	−18 16 27.7	9.342*n*	0.340*n*	+4.65	+12.8
26	12 05 51	17	10,	10	+0 18.27	−5 17.6	20 00 55.31	−18 19 00.8	9.398*n*	0.352*n*	+4.64	+12.6

Mean Places of Comparison Stars for the Beginning of the Year.

*	α	δ	Authority	*	α	δ	Authority
	h m s	° ′ ″			h m s	° ′ ″	
1	0 13 22.64	− 2 46 31.2	*A.G. Strassburg* 169	10	2 06 04.43	−13 50 58.3	*A.G. Washington* 564
2	0 51 02.87	− 5 19 31.8	*Cordoba Astr. Pl.* 6483	11	2 26 23.20	−16 49 26.7	*A.G. Washington* 653
3	1 05 50.64	− 7 30 08.0	*A.G. Wien-Ottak.* 232	12	2 26 11.41	−17 20 47.7	*A.G. Washington* 651
4	1 17 29.61	− 9 03 33.8	*A.G. Wien-Ottak.* 277	13	2 25 23.18	−17 37 37.3	*A.G. Washington* 646
5	1 25 24.13	− 9 55 05.2	*A.G. Cam. U. S.* 317	14	2 29 33.78	−17 57 25.4	*Cat. de Bordeaux* 544
6	1 36 14.46	−10 51 19.6	*A.G. Cam. U. S.* 363	15	23 11 08.45	+13 26 04.9	Micrometer comp. with *A.G. Leipzig I.* 9258
7	1 39 11.73	−11 29 10.3	*A.G. Cam. U. S.* 381	16	20 02 59.65	−18 09 05.4	*Cordoba Meridian Circle*
8	1 41 11.60	−11 44 16.3	*A.G. Cam. U. S.* 394	17	20 00 32.40	−18 13 55.8	*Cordoba Meridian Circle*
9	1 52 52.85	−12 37 44.4	*A.G. Cam. U. S.* 437				

NOTES

Apr. 20. Recorded by Prof. Perrine. *H. C. O. Bulletin*, 632.
24. Recorded by Mr. F. Symonds.
29. Large, diffuse.
May 5. No tail, no nucleus, maximum brightness not in center. Twilight. Diameter 1¼.
9. Through clouds.
14. No nucleus, large, diffuse.
18. No nucleus. Diameter 2, Magnitude 9.5.
25. Diameter 2.
June 2. Diameter 2.
21. Large, faint, difficult.
22. Large, faint, difficult.
24. Large, faint, difficult.
Apr. 30. Round, no nucleus, diameter 0′.8.
Aug. 23. Mag. 10.

Observatorio Nacional Argentino, Cordoba, Dec. 31, 1917.

The Cordoba meridian circle positions were reduced by the writer from observations by Mr. L. Guerin on Sept. 6 and 11, 1917, clamp west.

After Comet Mellish had passed the limiting visibility in the twelve-inch equatorial, a photographic search was made by Professor Perrine, assisted by Mr. F. P. Symonds, using the new reflector. Following is the record made by Professor Perrine:—

"The ephemeris positions of Comet Mellish were photographed on the nights of July 29, August 16, 17 and 18 with the 75 cm. reflector, with exposures of thirty minutes on the first date and one hour on the others. With the exception of July 29, the fields were photographed in duplicate. No trace of the comet was found on these plates. The mirror was not in good condition nor the guiding arrangements satisfactory, as the mounting had been hurried in order to obtain these photographs. The star images were sufficiently good to have shown the comet had it been sufficiently bright. It could hardly have been as bright as 15th magnitude."

FOUR PROPER-MOTIONS,

By A. ESTELLE GLANCY.

The following constitutes an appendix to Mean Places of Comparison Stars, *A. J.* No. 731.

The proper-motions of all comparison stars which have been reobserved have been determined when possible. The following list gives those stars which have no proper-motion larger than the uncertainty of the observations compared. The table gives the number of the comparison star, its designation and the interval between the earliest and latest catalogs compared.

For star 11, *C.D.* −46°, 2024, the proper-motion is

$$\mu_\alpha = -0^s.006$$
$$\mu_\delta = +0''.01$$

*	Designation	Years	*	Designation	Years
8	*C.D.* −51°, 1539	35	69	*A.G. Nic.* 4414	32
9	*C.D.* −50°, 1864	40	71	*A.G. Nic.* 4420	32
14	*C.D.* −39°, 2354	35	73	*A.G. Nic.* 4446	39
20	*C.D.* −28°, 3015	29	74	*C.D.* −39°, 12027	35
23	*C.D.* −28°, 3043	36	75	*C.D.* −34°, 12289	42
24	*C.D.* −25°, 3294	23	77	*C.D.* −37°, 12036	35
25	*C.D.* −26°, 3079	23	80	*C.D.* −35°, 12142	40
26	*C.D.* −25°, 3305	23	81	*A.G. Nic.* 4500	39
27	*C.D.* −26°, 3084	23	83	*B.D.* −21°, 5292	38
28	*C.D.* −22°, 3203	40	84	*C.D.* −23°, 15181	23
35	*C.D.* −27°, 9226	29	87	*C.D.* −25°, 13969	21
40	*C.D.* −51°, 8631	40	88	*C.D.* −27°, 13917	20
52	*C.D.* −55°, 6476	36	96	*B.D.* −16°, 6082	21
54	*C.D.* −30°, 13134	36	97	*B.D.* −18°, 6129	21
55	*C.D.* −30°, 13229	30	100	*C.D.* −26°, 16385	20
61	*C.D.* −52°, 7860	33	102	*C.D.* −32°, 17434	38
68	*A.G. Alb.* 5901	36			

according to the *Cape Catalog of Standard Astrographic Stars*, 1900. A new reduction would make μ_α a little smaller numerically.

Star 57, *C.D.* −53°, 6829, may have a small negative proper-motion, but it is doubtful.

For star 64, *B.D.* −2°, 3302, the proper-motion is

$$\mu_\alpha = -0^s.007$$
$$\mu_\delta = -0''.19$$

according to PORTER in *Cincinnati Publ.*, Vol. 12. The Cordoba position is consistent with these values.

Star 79, *C.D.* −33°, 12700 shows a small negative progression in R. A. in 64 years (0^s.10). Although this amount is within the usual uncertainty of the catalog places, it may be real, for this star has been well observed.

For star 89, *C.D.* −31°, 16750, the proper-motion is

$$\mu_\alpha = 0^s.000 \qquad \mu_\delta = -0''.27$$

according to PORTER in *Cincinnati Publ.*, Vol. 12. The new Cordoba position is consistent with these values.

Star 102, *C.D.* −32°, 17434. This is *Argentine General Catalog* (2), 5575. The following correction should be made in the catalog declination. For 53″.6 read 33″.6.

The proper-motions deduced below were derived as follows.

The catalog positions were most conveniently brought up to the beginning of the year 1900 by using the precession factors given in one of the Cordoba catalogs. This is equivalent to the use of the constants of STRUVE and PETERS.

No correction has been added to any of the catalogs used, but they have been given the respective weights found in Boss' *P.G.C.*

For the new Cordoba observations the following weights have been assigned on the same basis. They were derived from comparison of the probable errors with those for the *Cape Catalog of Astrographic Standard Stars*, 1900, for which Boss has assigned a weight.

No. Obs.	Wgt.
1	0.3
2–3	0.5
4–5	1.0

The same weight has been arbitrarily assigned to the *Second Argentine General Catalog* and to *Cordoba B*.

COMPARISON STAR 70, *C.D.* −27°, 11991 1900.0 $17^h\,44^m\,00^s+$ −27° 01′ 40″ −

Designation	Wgt.	Epoch 1800+	Seconds of R. A. before	Seconds of R. A. after	Wgt.	Epoch 1800+	Seconds of Dec. before	Seconds of Dec. after
			s	s			″	″
PIAZZI XVII, 238	0.05	00	5.96	5.76	0.05	00	− 1.2	− 5.3
TAYLOR 8239	0.05	35.5	6.20	6.07	0.15	34.5	− 2.1	− 4.8
Cape 1850, 3391	0.15	52.6	5.84	5.75	0.20	50.3	− 4.4	− 6.4
YARNALL 7563	0.30	62.5	5.71	5.64	0.20	65.4	− 3.8	− 5.2
Cape 1880, 9716	0.50	77.0	5.78	5.74	2.00	76.2	− 5.4	− 6.4
Arg. Gen. (1), 24210	0.35	77.1	5.79	5.75	0.40	77.1	− 4.2	− 5.1
Cordoba B, 11350	0.50	94.3	5.76	5.75	0.50	94.3	− 5.7	− 5.9
Cape 1900, 2429	1.50	102.6	5.75	5.75	1.50	102.6	− 6.2	− 6.1
Comp. Star 70	1.00	115.7	5.68	5.71	1.00	115.7	− 6.3	− 5.7

Weighted mean position 1900.0 $17^h\,44^m\,05^s.75$ −27° 01′ 46″.0

$\mu_\alpha = -0^s.002$ $\mu_\delta = -0''.04$

COMPARISON STAR 72, *C.D.* −27°, 12009 1900.0 $17^h\,44^m\,50^s+$ −27° 21′ 40″ −

Designation	Wgt.	Epoch 1800+	Seconds in α before	Seconds in α after	Wgt.	Epoch 1800+	Seconds in δ before	Seconds in δ after
			s	s			″	″
Arg. S.Z. 13688	0.05	19.5	1.66	1.42	0.05	19.5	− 2.7	−10.8
Cord. C.Z. 17^h, 2927	0.05	73.6	1.37	1.25	0.05	73.6	− 8.8	−13.1
Cord. B. 11361	0.50	93.6	1.25	1.22	0.50	93.6	− 9.1	−10.1
Comp. Star 72	1.00	115.7	1.21	1.28	1.00	115.7	−13.3	−10.8

Weighted mean position 1900.0 $17^h\,44^m\,51^s.27$ −27° 21′ 50″.6

$\mu_\alpha = -0^s.005$ $\mu_\delta = -0''.16$

COMPARISON STAR 91, *C.D.* −38°, 13832 1900.0 19ʰ 57ᵐ 24ˢ.0+ −38° 08′ 00″−

Designation	Wgt.	Epoch 1800+	Seconds in α before	Seconds in α after	Wgt.	Epoch 1800+	Seconds in δ before	Seconds in δ after
			s	s			″	″
PIAZZI XIX, 359	...	....	...	...	0.10	00	− 4.6	−43.5
TAYLOR 9203	0.10	37.4	0.05	0.25	0.15	37.6	−20.4	−44.7
YARNALL 8852	0.20	62.7	0.11	0.23	0.30	70.7	−32.3	−43.7
Arg. Gen. (1), 27452	0.40	75.6	0.16	0.24	0.50	75.6	−33.9	−43.4
Cape 1880. 10770	0.35	78.0	0.33	0.40	1.00	78.0	−35.9	−44.5
Arg. Gen. (2) 5000	1.00	85.7	0.28	0.33	1.00	85.7	−38.7	−14.3
Comp. Star 91	1.00	116.5	0.34	0.29	1.00	116.5	−50.4	−41.0

Weighted mean position 1900.0 19ʰ 57ᵐ 24ˢ.30 −38° 08′ 44″.1
μ_α = +0ˢ.003 μ_δ = −0″.39

COMPARISON STAR 104, *C.P.D.* −72°, 2757 1900.0 23ʰ 15ᵐ 10ˢ+ −72° 07′ 10″−

Designation	Wgt.	Epoch 1800+	Seconds in α before	Seconds in α after	Wgt.	Epoch 1800+	Seconds in δ before	Seconds in δ after
			s	s			″	
GILLIS 16307	0.10	51.7	5.88	6.79	0.05	51.7	− 8.6	....
Cord. Z.C. 23ʰ,369	0.05	73.9	(7.00)*	(7.49)	0.05	73.9	− 7.6	...
Arg. Gen. (1), 31626	0.35	80.8	6.47	6.83	0.50	80.8	− 9.4	....
C.P.D. −72°, 2757	0.05	85.8	6.40	6.69	...	...	.....	....
Comp. Star 104	1.00	115.8	7.09	6.79	1.00	115.8	− 9.7	...

*Not used.

The weight of the Cordoba and Cape Zone positions has been assigned arbitrarily.
Weighted mean position 1900.0 23ʰ 15ᵐ 56ˢ.77 −72° 07′ 19″.1
μ_α = +0ˢ.019 μ_δ = ±0″.00

So far as is known to the writer, these proper-motions have not been previously published. They have not been applied to the comparison star positions.

Observatorio Nacional Argentino, Cordoba, August, 1917.

OBSERVATIONS OF *EROS*,

MADE WITH THE 12-INCH EQUATORIAL AT THE NATIONAL ARGENTINE OBSERVATORY, CORDOBA,

BY A. ESTELLE GLANCY.

Date Gr. M. T.	*	Comp. α δ	Δα	Δδ	App. α	App. δ	Log. p Δ α	Log. p Δ δ	Red. to App. Pl. α	Red. to App. Pl. δ
1917 d h m s			m s	′ ″	h m s	° ′ ″			s	″
Mar. 29 16 06 18	1	12*t* 12	+1 02.11	−4 26.5	15 21 30.37	−48 25 18.7	9.735*n*	9.943	+3.69	−5.8
30 16 48 56	2	7*t* 7	−1 43.51	+3 21.5	15 20 58.18	−48 38 07.7	9.630*n*	0.227	+3.74	−5.8
Apr. 2 17 37 26	3	12*t* 12	+0 38.95	−5 01.3	15 18 52.24	−49 12 45.4	9.388*n*	0.383	+3.86	−6.7
2 17 56 40	4	10*t* 10	+0 30.89	+2 43.9	15 18 51.19	−49 12 49.7	9.261*n*	0.407	+3.86	−6.7
4 16 57 34	5	10*t* 10	+0 38.45	−1 35.6	15 17 05.61	−49 32 09.9	9.532*n*	0.337	+3.93	−7.1
5 15 29 24	6	12*t* 12	+0 22.43	+3 29.6	15 16 08.24	−49 40 26.6	9.753*n*	9.979	+3.96	−7.4
7 16 07 52	7	10*t* 10	−0 56.34	+2 15.0	15 13 49.34	−49 56 35.4	9.648*n*	0.252	+4.02	−7.8
10 15 36 41	8	10*t* 10	−2 57.18	+5 17.2	15 09 50.65	−50 14 50.8	9.690*n*	0.202	+4.14	−8.4
13 15 23 06	9	11*t* 11	+1 03.79	+5 09.8	15 05 12.42	−50 26 18.4	9.685*n*	0.231	+4.25	−9.9

t signifies transits. Mar. 30, through clouds.

Mean Places for the Beginning of the Year.

*	α	δ	Designation of Star
	h m s	° ′ ″	°
1	15 20 24.57	−48 20 46.4	*Cordoba Durchmusterung* −48 , 9940
2	15 22 37.95	−48 41 23.4	*Cordoba Durchmusterung* −48 , 9976
3	15 18 09.43	−49 07 37.4	*Cordoba Durchmusterung* −48 , 9904
4	15 18 16.14	−49 15 26.9	*Cordoba Durchmusterung* −49 , 9587
5	15 16 23.23	−49 30 27.2	*Cordoba Durchmusterung* −49 , 9564
6	15 15 41.85	−49 43 48.8	*Cordoba Durchmusterung* −49 , 9548
7	15 14 41.66	−49 58 42.6	*Cordoba Durchmusterung* −49 , 9535
8	15 12 43.69	−50 19 59.6	*Cordoba Durchmusterung* −50 , 9259
9	15 04 04.38	−50 31 18.3	*Cordoba Durchmusterung* −50 , 9126

The positions of comparison stars were deduced by the writer from Cordoba meridian circle observations by Señor L. Guerin. The R. A. has been corrected for a mean magnitude equation.

$$-0^s.007 \text{ (mag. } -4.0)$$

The probable errors of a single observation are $\pm 0^s.023$ sec δ and $\pm 0''.55$. Each position is the mean of four observations, two west and two east. There is a systematic equatorial difference between east and west amounting to

$$0^s.06 \cos 49°$$

Since the number of observations is the same for both clamps the accidental error is really smaller than given and the systematic error is eliminated. This systematic difference is probably due to the fact that the collimation was determined with bright field and the observations were made with red illuminated wires, a matter which has not yet been investigated.

The probable error in declination could be reduced by arbitrarily changing the constant of refraction on the first date of observation.

Star 1 is *Cordoba Zone Catalog* 15h.1190. A comparison of positions indicates

$$\mu_\alpha = -0^s.01 \qquad \mu_\delta = -0''.1$$

Observatorio Nacional, Cordoba, Dec. 11, 1917.

OBSERVATIONS OF THE SEVENTH AND EIGHTH SATELLITES OF *JUPITER*.

By SETH B. NICHOLSON.

The following positions of *Jupiter's* Seventh and Eighth Satellites were obtained from plates taken with the Crossley reflector at the Lick Observatory during the opposition of 1914. Plates 3057 and 3060 were taken to secure positions of the Eighth Satellite. The other exposures were made primarily for the Ninth, its motion being used in guiding (*Lick Observatory Bulletin* 265). These plates were measured and reduced in 1914, a description of the methods used with the identification and positions of the comparison stars being given in *Lick Observatory Bulletin* 271. The observed positions of the Eighth Satellite are compared with the ephemeris by A. C. D. Crommelin (*Monthly Notices*, 71, 50, 1910). It is of interest to note that images of all three satellites were measured on Plate 3095. A few plates of the Sixth Satellite were also secured at that opposition but have not been measured.

Seventh Satellite

Gr. Mean Time 1914	α 1914.0	δ 1914.0	Log pΔ α	Log pΔ δ	Plate	Exp.	Stars (*L. O. B.* 271)
d h m	h m s	° ′ ″				h m	
Sept. 20 17 51.8	20 59 10.46	−17 50 6.4	8.992	0.854	3089	2 30	21, 22, 23, 24, 25, 26
Sept. 21 17 35.3	20 58 59.18	−17 50 18.8	8.818	0.856	3095	2 00	21, 22, 23, 24, 27
Sept. 21 19 18.3	20 58 58.67	−17 50 19.4	9.435	0.834	3096	1 00	21, 22, 23, 24, 27

EIGHTH SATELLITE

Gr. Mean Time 1914	α (1914.0)	δ (1914.0)	Log pΔ α	Log pΔ δ	Plate	Exp.	O − C cos δΔα	O − C Δδ	Stars (*L. O. B.* 271)
d h m	h m s	° ′ ″				h m	″	″	
July 21 21 49.3	21 22 13.10	−15 28 40.6	8.545	0.845	3057	2 15	+ 5.7	−10.5	2, 3, 4, 5
July 22 21 38.9	21 21 45.91	−15 30 40.4	8.351	0.845	3060	2 15	+ 5.8	−10.7	1, 2, 3, 4, 5
July 23 21 59.7	21 21 17.78	−15 32 44.8	8.876	0.844	3062	2 30	+ 6.0	−11.4	2, 3, 4, 6
July 24 22 5.8	21 20 49.59	−15 34 48.0	8.988	0.843	3064	2 34	+ 5.8	−10.6	2, 3, 4, 6
July 31 22 0.1	21 17 25.50	−15 49 16.7	9.172	0.842	3073	2 33	+ 3.1	−10.3	7, 8, 9, 10, 11
Aug. 23 19 40.8	21 6 1.55	−16 40 15.5	8.846	0.851	3085	2 00	− 6.6	− 7.0	12, 13, 14, 15
Sept. 21 17 35.3	20 56 18.75	−17 26 9.2	8.818	0.856	3095	2 00	−22.0	− 0.7	21, 22, 23, 24, 27
Sept. 21 19 18.3	20 56 17.97	−17 26 13.9	9.435	0.834	3096	1 00	−22.1	− 1.3	21, 22, 23, 24, 27

Mt. Wilson Solar Observatory, January, 1918.

OBSERVATIONS OF ASTEROIDS,

MADE WITH THE PHOTOGRAPHIC TELESCOPE OF THE U. S. NAVAL OBSERVATORY,

By GEORGE H. PETERS.

[Communicated by Rear Admiral T. B. HOWARD, U. S. Navy, Superintendent.]

Name	Mag.	Date 1917	G. M. T.	α 1917.0	δ 1917.0
			h m	h m s	° ′ ″
(58) *Concordia*	11.6	Jan. 16	15 05.0	6 46 18.0	+16 35 12
(358) *Apollonia*	12.0	Jan. 16	16 10.8	8 18 07.5	+15 05 00
(58) *Concordia*	11.6	Jan. 19	14 00.5	6 43 45.2	+16 43 47
(358) *Apollonia*	12.0	Jan. 19	16 01.4	8 15 26.0	+15 16 16
(584) *Semiramis*	11.8	Jan. 30	15 11.5	8 04 29.3	+13 39 24
(584) *Semiramis*	11.8	Feb. 14	13 24.8	7 50 32.8	+13 44 28
(37) *Fides*	10.0	Feb. 17	15 46.5	9 50 08.6	+16 46 23
(119) *Althæa*	10.9	Feb. 17	16 35.0	9 24 36.6	+ 7 01 49
(115) *Thyra*	10.4	Feb. 17	16 35.0	9 31 41.7	+ 8 48 40
(37) *Fides*	10.0	Feb. 20	15 03.3	9 47 18.4	+16 56 43
(119) *Althæa*	10.9	Feb. 20	15 51.8	9 22 04.4	+ 7 19 15
(115) *Thyra*	10.4	Feb. 20	15 51.8	9 28 25.4	+ 8 50 49
(130) *Elektra*	11.1	Feb. 24	15 05.8	10 07 58.0	+14 27 44
(442) *Eichsfeldia*	11.9	Feb. 24	15 05.8	10 14 37.8	+14 28 41
(130) *Elektra*	11.1	Mar. 12	14 16.0	9 57 19.9	+16 34 43
(442) *Eichsfeldia*	11.9	Mar. 12	14 16.0	10 01 03.9	+16 26 27
(129) *Antigone*	9.8	Mar. 12	15 03.0	10 48 16.3	+16 41 27
(129) *Antigone*	9.8	Mar. 15	15 05.0	10 46 01.0	+17 05 44
(447) *Valentine*	12.5	Mar. 19	14 43.7	10 52 37.2	+14 41 40
(201) *Penelope*	12.8	Mar. 19	15 51.2	11 12 37.5	+ 7 09 38
(447) *Valentine*	12.5	Mar. 22	14 32.4	10 50 31.8	+14 50 46
(201) *Penelope*	12.8	Mar. 22	15 43.9	11 10 20.4	+ 7 27 55
(18) *Melpomene*	10.3	Mar. 22	16 37.9	11 12 32.3	+11 10 53
(18) *Melpomene*	10.3	Mar. 24	15 24.8	11 10 56.3	+11 25 27
(194) *Prokne*	11.4	Mar. 24	16 12.3	11 39 32.1	+10 35 40
(194) *Prokne*	11.4	Mar. 27	16 16.4	11 37 13.6	+11 02 53
(86) *Semele*	13.3	Mar. 28	16 26.5	12 03 14.0	+ 6 46 08
(86) *Semele*	13.3	Mar. 30	16 38.8	12 01 49.2	+ 6 54 25
(489) *Comacina*	12.3	Apr. 13	16 12.3	13 28 21.4	+ 2 17 06

Name	Mag.	Date 1917	G. M. T.	α 1917.0	δ 1917.0
			h m	h m s	° ′ ″
(380) *Fiducia*	12.9	Apr. 13	16 12.3	13 29 51.4	+ 0 23 22
(213) *Lilaea*	11.1	Apr. 13	16 12.3	13 32 54.7	+ 1 52 01
(752) [1913 *R L*]	13.2	May 1	16 54.8	15 38 12.6	−13 46 07
(536) *Merapi*	11.9	May 1	16 54.8	15 45 55.0	−16 26 59
(380) *Fiducia*	12.9	May 10	14 49.5	13 09 21.2	+ 1 40 36
(213) *Lilaea*	11.4	May 10	14 49.5	13 13 09.8	+ 3 26 14
(489) *Comacina*	12.3	May 11	15 03.0	13 12 07.7	+ 4 44 12
(536) *Merapi*	11.9	May 11	16 25.6	15 38 05.4	−16 36 21
(122) *Gerda*	11.2	May 11	16 25.6	15 38 38.9	−17 27 11
(92) *Undina*	11.1	May 12	15 14.7	13 47 30.2	+ 2 54 01
(455) *Bruchsalia*	12.3	May 12	15 14.7	13 54 26.7	+ 1 01 43
(92) *Undina*	11.1	May 14	15 00.7	13 46 18.8	+ 2 54 49
(455) *Bruchsalia*	12.3	May 14	15 00.7	13 52 50.5	+ 1 02 21
(536) *Merapi*	11.9	May 14	16 17.7	15 35 38.0	−16 39 04
(122) *Gerda*	11.2	May 14	16 17.7	15 36 18.4	−17 18 18
(536) *Merapi*	11.9	May 23	16 29.0	15 28 11.4	−16 47 33
(122) *Gerda*	11.2	May 23	16 29.0	15 29 17.5	−16 51 35
(536) *Merapi*	11.9	May 25	16 10.5	15 26 34.2	−16 49 32
(122) *Gerda*	11.2	May 25	16 10.5	15 27 47.2	−16 45 41
(173) *Ino*	11.7	June 13	15 11.6	15 35 13.5	+ 1 26 33
(173) *Ino*	11.7	June 18	15 24.1	15 32 09.6	+ 1 17 26

ON THE MOTION OF A FAINT STAR IN *AQUARIUS*.

By C. O. LAMPLAND.

In examining with the comparator a pair of negatives of the planetary nebula in *Aquarius*, *N. G. C.* 7009, I found in the field following and north of the nebula a faint star with motion. These negatives were made with the 40-inch Lowell reflector on August 29, 1911, and November 5, 1917. From measurements of the star on plates of the same region taken August 29, 1911, August 24, 1914, October 26, 1916 and November 5, 1917, the following values were found for the components of the annual motion

$$\mu_\alpha = +0^s.036$$
$$\mu_\delta = -0''.16$$
or
$$0''.55 \text{ in } 107^\circ$$

As the star on these photographs is about 24′ from the optical axis the image is not well suited to accurate measurement, and only approximate values can at this time be given for the motion and the magnitude.

The star is about magnitude 14 and its position

$$\left.\begin{array}{ll}\text{R. A.} & = 20^h\,59^m.8 \\ \text{Dec.} & = -11^\circ\,28'\end{array}\right\}(1900)$$

It is situated with reference to the catalogue star *B. D.* −11, 5515 in P. A. 80°.5 and distance 4′.2.

Lowell Observatory, Flagstaff, Arizona, January 10, 1918.

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Observations, by A. Estelle Glancy.
Four Proper-Motions, by A. Estelle Glancy.
Observations of *Eros*, by A. Estelle Glancy.
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Observations of Asteroids, by George H. Peters.
On the Motion of a Faint Star in *Aquarius*, by C. O. Lampland.

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THE *MOON'S* MEAN LONGITUDE AND THE ECLIPSE OF JUNE 8, 1918,

By ARTHUR NEWTON.

[Communicated by Rear Admiral THOS. B. HOWARD, U. S. Navy, Superintendent U. S. Naval Observatory.]

The present paper is the third of a series; the two earlier papers were prepared by DR. FRANK E. ROSS and appeared in the *Astronomical Journal*, Nos. 667 and 681.

Of the 109 occultation phenomena tabulated below, 13 were observed at Greenwich and the observations are recorded in *Monthly Notices* for January, 1916, and for January, 1917. The remaining 96 phenomena were observed at Washington and the observations are recorded in *A. J.*, Nos. 688 and 725.

As in the previous reductions, only occultations were utilized that were nearly central. All bright limb emersions were discarded in the present work at the very outset. For the remaining phenomena, equal weight was given, as hitherto, to observations by the 12-inch and by the 26-inch telescope.

The method of reduction is precisely the same as that described in *A. J.*, No. 681; the equation for determining the correction to the mean longitude, δM, being

$$E \cdot \delta M = s' - D,$$

where s' is the semi-diameter of the *Moon*, and D the computed distance between the occulted star and the *Moon's* center. Each occultation therefore gives a determination of δM of weight E^2.

The values of δM in the following tabulation accordingly give the correction to: pure theory plus NEWCOMB's long-period empirical term. They are therefore identical with the "minor residuals" of NEWCOMB. The last column, v, contains the residuals obtained by substituting in the equations of condition the smooth-curve values of δM.

TABLE I

MOON'S LONGITUDE FROM OCCULTATIONS, 1915–17

Place	Date	Star	Phen.	Tabular Corrections to HANSEN-NEWCOMB			E	$s'-D$	δM	v
				$\delta\lambda$	$\delta\beta$	$\delta\pi$				
				″	″	″		″	″	″
G	1915 Feb. 21	18 *Tauri*	DD	+7.73	− .03	+ .40	− .89	− 7.9	+ 8.9	−1.1
G	Mar. 26	139 *B. Cancri*	DD	7.37	− .08	.44	− .99	− 7.8	7.9	−0.2
W	Apr. 21	82 *Geminorum*	DD	8.18	− .02	.43	− .57	− 4.0	7.0	+0.4
G	23	227 *B. Cancri*	DD	7.88	− .15	.44	− .76	− 5.4	7.1	+0.5
W	May 5	ι *Capricorni*	RD	3.49	− .25	.46	+ .97	+ 5.9	6.1	−1.7
W	21	*A Leonis*	DD	8.52	− .05	.46	− .94	− 8.0	8.5	−0.7
W	June 4	13 *Piscium*	DB	4.40	− .78	.44	− .80	− 5.7	7.1	+0.5
W	4	13 *Piscium*	RD	4.43	− .78	.44	+ .57	+ 5.6	9.8	+1.2
W	27	51 *Sagittarii*	DB	3.50	− .18	.49	− .80	− 8.6	10.8	−2.3
W	27	*h Sagittarii*	DB	3.50	− .19	.49	−1.11	− 8.5	7.7	+0.3
W	27	51 *Sagittarii*	RD	3.48	− .20	.49	+ .98	+ 7.6	7.8	−0.1
W	27	*h Sagittarii*	RD	3.48	− .21	.49	+1.06	+ 8.1	7.6	−0.3
G	July 28	67 *Aquarii*	DB	3.60	−1.20	.45	− .97	− 9.1	9.4	−1.4
W	Aug. 23	42 *Capricorni*	DD	+5.55	− .55	+ .47	− .98	− 7.9	+ 8.1	−0.2

Place	Date	Star	Phen.	Tabular Corrections to Hansen-Newcomb			E	$s'-D$	δM	r
				$\delta\lambda$	$\delta\beta$	$\delta\pi$				
						″		′	″	″
W	1915 Sept. 21	197 *G. Aquarii* . . .	DD	+6.27	− .59	+.45	− .71	− 3.9	+ 5.5	+1.8
W	27	20 *Tauri*	DB	4.85	− .02	.40	− .89	− 6.4	7.2	+0.7
W	27	16 *Tauri*	RD	4.84	− .02	.40	+ .91	+ 6.7	7.4	−0.6
W	27	20 *Tauri*	RD	4.84	− .02	.40	+ .91	+ 6.5	7.1	−0.8
W	29	112 *B. Aurigæ*	RD	4.67	+ .40	.40	+ .79	+ 4.9	6.2	−1.4
W	Oct. 2	49 *B. Cancri*	DB	5.24	+ .35	.42	− .86	− 7.6	8.8	−0.7
W	2	49 *B. Cancri*	RD	5.25	+ .35	.42	+ .90	+ 7.5	8.3	+0.3
W	13	10 *G. Sagittarii* . . .	DD	5.33	+ .79	.50	−1.07	− 7.3	6.8	+1.3
W	15	336 *B. Sagittarii* .	DD	5.48	+ .38	.49	− .82	− 7.2	8.8	−0.6
W	25	χ *Tauri*	DB	5.18	+ .41	.40	− .82	− 6.8	8.3	−0.3
W	25	χ *Tauri*	RD	5.17	+ .42	.40	+ .61	+ 4.7	7.7	−0.2
W	30	*X Cancri*	DB	5.14	+ .39	.42	− .82	− 6.9	8.4	−0.4
W	Nov. 25	187 *B. Geminorum*	DB	4.53	+ .92	.41	− .56	− 7.4	13.2	−3.0
W	25	187 *B. Geminorum*	RD	4.53	+ .92	.41	+ .64	+ 4.6	7.2	−0.6
W	Dec. 18	20 *Tauri*	DD	5.05	+ .43	.41	− .86	− 7.2	8.4	−0.2
W	18	22 *Tauri*	DD	5.05	+ .44	.41	− .59	− 4.0	6.8	+0.7
G	18	16 *Tauri*	DD	5.05	+ .46	.41	− .80	− 7.5	9.4	−1.0
G	18	*q Tauri*	DD	5.04	+ .46	.40	− .89	− 7.0	7.9	+0.2
G	18	20 *Tauri*	DD	5.04	+ .46	.40	− .86	− 5.9	6.9	+1.1
G	18	21 *Tauri* . . .	DD	5.04	+ .46	.40	− .82	− 6.2	7.6	+0.5
G	18	22 *Tauri* . . .	DD	5.04	+ .46	.40	− .87	− 8.0	9.2	−1.0
W	21	ε *Geminorum*	DB	4.53	+1.20	.40	− .90	− 7.1	7.9	+0.2
W	21	ε *Geminorum*	RD	4.52	+1.20	.40	+ .87	+ 6.7	7.7	−0.4
W	22	*B.D.* +23° 1744 . .	DB	4.37	+1.20	.41	− .80	− 8.9	11.1	−2.4
W	22	*B.D.* +23° 1744 . .	RD	4.37	+1.20	.41	+ .90	+10.0	11.1	+2.7
W	1916 Jan. 14	*q Tauri*	DD	5.06	+ .22	.40	− .87	− 5.6	6.4	+1.4
W	14	21 *Tauri*	DD	5.06	+ .22	.40	− .90	− 7.9	8.8	−0.6
W	14	22 *Tauri* . . .	DD	5.06	+ .22	.40	− .90	− 7.8	8.7	−0.5
G	15	χ *Tauri* . . .	DD	4.98	+ .47	.40	− .59	− 5.1	8.6	−0.3
W	18	48 *Geminorum* . . .	DD	4.65	+1.20	.41	− .83	− 8.6	10.4	−1.9
W	Feb. 14	ω *Geminorum* . .	DD	5.48	+ .87	.40	− .88	− 5.5	6.3	+1.6
W	Mar. 23	65 *B. Scorpii* . . .	DB	3.54	+ .67	.48	− .88	− 8.0	9.4	−0.8
W	23	65 *B. Scorpii* . . .	RD	3.52	+ .67	.48	+ .89	+ 5.6	6.3	−1.7
W	24	95 *G. Ophiuchi* . . .	DB	3.02	+ .61	.49	−1.05	− 8.8	8.4	−0.2
G	May 8	d^1 *Cancri*	DD	7.25	+ .61	.40	− .80	− 8.1	10.1	−1.5
W	June 13	*b Scorpii*	DD	5.44	+ .08	.49	− .98	− 8.1	8.3	−0.1
W	18	29 *Capricorni* . .	DB	2.98	− .68	.49	−1.05	− 6.6	6.3	+2.0
W	18	29 *Capricorni* . . .	RD	2.98	− .69	.49	+1.11	+ 7.3	6.6	−1.8
W	22	136 *B. Piscium* . .	DB	3.99	− .81	.46	− .68	− 5.4	8.0	+0.1
W	July 23	23 *Tauri*	RD	4.77	+ .09	.42	+ .80	+ 4.8	6.0	−1.8
W	23	24 *Tauri*	DB	4.77	+ .08	.42	− .92	− 5.1	5.6	+2.5
W	23	η *Tauri*	DB	4.77	+ .08	.42	− .92	− 5.6	6.1	+2.1
W	23	28 *Tauri* . . .	DB	4.78	+ .10	.42	− .86	− 4.0	4.7	+3.1
W	23	η *Tauri*	RD	4.78	+ .10	.42	+ .88	+ 3.7	4.2	−3.6
W	23	28 *Tauri* . . .	RD	4.80	+ .11	.42	+ .67	+ 5.0	7.5	−0.5
W	Aug. 7	*b Scorpii*	DD	7.30	+ .52	.49	−1.01	− 6.7	6.6	+1.7
W	10	189 *B. Sagittarii* .	DD	5.61	+ .10	.50	− .98	− 6.6	6.7	+1.5
W	12	29 *Capricorni* . .	DD	+4.54	− .52	+.49	−1.14	− 8.3	+ 7.3	+1.1

Place	Date	Star	Phen.	Tabular Corrections to Hansen-Newcomb δλ	δβ	δπ	*E*	*s′ − D*	δ*M*	*v*
				″	″	″		″	″	″
G	1916 Sept. 15	ε *Arietis*	RD	+4.40	− .33	+ .43	+ .68	+ 5.8	+ 8.5	+0.1
G	16	27 *Tauri*	RD	4.34	− .04	.42	+ .80	+ 6.8	8.5	+0.2
W	Oct. 7	ρ *Aquarii*	DD	6.63	− .12	.49	−1.04	− 6.7	6.4	+1.9
W	13	17 *Tauri*	DB	5.22	+ .18	.43	− .58	− 4.5	7.8	+0.3
W	13	23 *Tauri*	DB	5.22	+ .18	.43	− .97	− 9.6	9.9	−1.6
W	13	17 *Tauri*	RD	5.21	+ .19	.43	+ .56	+ 6.4	11.4	+1.8
W	13	η *Tauri*	DB	5.21	+ .20	.43	− .88	− 7.1	8.1	+0.2
W	13	23 *Tauri*	RD	5.20	+ .20	.43	+ .97	+ 8.8	9.1	+0.8
W	13	27 *Tauri*	DB	5.20	+ .20	.43	− .97	− 8.2	8.5	−0.2
W	13	28 *Tauri*	DB	5.20	+ .21	.43	− .88	− 7.5	8.5	−0.2
W	13	η *Tauri*	RD	5.20	+ .21	.43	+ .80	+ 5.7	7.1	−0.9
W	19	o^1 *Cancri*	RD	5.58	+ .78	.40	+ .65	+ 7.5	11.5	+2.1
W	19	o^2 *Cancri*	RD	5.59	+ .78	.40	+ .83	+ 7.1	8.6	+0.2
W	Nov. 10	36 *Tauri*	DB	6.20	+ .48	.44	− .94	− 7.1	7.6	+0.7
W	10	36 *Tauri*	RD	6.19	+ .51	.43	+ .96	+ 6.9	7.2	−1.1
W	Dec. 2	16 *Piscium*	DD	7.15	− .35	.48	− .88	− 6.3	7.2	+1.0
W	5	47 *B. Arietis*	DD	7.32	− .08	.45	− .98	− 5.8	5.9	+2.4
W	26	π *Capricorni*	DD	5.11	− .32	.50	− .91	− 7.8	8.6	−0.3
W	1917 Jan. 7	δ *Geminorum*	DE*	6.43	+1.48	.40	− .91	− 9.4	10.3	−1.9
W	7	δ *Geminorum*	RE*	6.43	+1.48	.40	+ .86	+ 7.2	8.4	+0.1
W	8	85 *Geminorum*	RD	6.40	+1.52	.40	+ .90	+ 8.1	9.0	+0.6
W	8	217 *B. Geminorum*	DB	6.40	+1.52	.40	− .59	− 6.1	10.3	−1.2
W	11	155 *B. Leonis*	RD	6.59	+1.03	.41	+ .89	+ 7.5	8.4	+0.1
W	26	19 *Piscium*	DD	5.97	− .79	.49	−1.09	− 6.6	6.1	+2.4
W	Feb. 3	44 *Geminorum*	DD	6.35	+1.23	.40	− .90	− 8.4	9.3	−0.9
W	Mar. 6	83 *B. Leonis*	DD	6.43	+ .96	.40	− .75	− 6.4	8.5	−0.2
W	6	89 *B. Leonis*	DD	6.43	+ .95	.40	− .80	− 7.0	8.7	−0.3
W	6	π *Leonis*	DD	6.42	+ .94	.40	− .90	− 8.1	9.0	−0.6
W	31	10 *H. Cancri*	DD	6.92	+ .95	.40	− .79	− 8.9	11.3	−2.4
W	Apr. 3	155 *B. Leonis*	DD	7.18	+ .60	.41	− .91	− 8.8	9.7	−1.3
W	10	σ *Scorpii*	DB	3.67	+ .11	.47	− .95	− 5.8	6.1	+2.1
W	10	σ *Scorpii*	RD	3.65	+ .11	.47	+ .96	+ 7.0	7.3	−1.0
W	14	σ *Capricorni*	RD	3.14	+ .20	.50	+ .88	+ 5.8	6.6	−1.5
W	June 25	p^3 *Leonis*	DD	7.43	+ .76	.41	− .90	− 7.4	8.2	0.0
W	Aug. 5	19 *Piscium*	DB	3.72	− .46	.49	−1.09	− 7.5	6.9	+1.6
W	5	19 *Piscium*	RD	3.71	− .46	.49	+1.10	+ 6.1	5.5	−3.0
W	7	101 *Piscium*	DB	3.43	− .33	.48	− .97	− 7.1	7.3	+0.9
W	28	222 *B. Sagittarii*	DD	6.06	+ .36	.49	− .86	− 7.9	9.2	−0.8
W	Sept. 6	161 *B. Tauri*	DB	3.15	+ .31	.46	− .98	− 9.4	9.6	−1.3
W	6	161 *B. Tauri*	RD	3.15	+ .32	.46	+1.00	+10.6	10.6	+2.3
W	26	95 *B. Capricorni*	DD	6.70	+ .54	.50	− .98	− 8.5	8.7	−0.3
W	29	19 *Piscium*	DD	5.71	+ .14	.49	−1.07	− 8.4	7.9	+0.5
W	30	136 *B. Piscium*	DB	5.24	+ .04	.49	−1.03	−12.6	12.2	−4.1
W	Oct. 4	95 *Tauri*	DB	3.33	+ .67	.45	−1.01	−11.8	11.7	−3.4
W	4	95 *Tauri*	RD	3.32	+ .68	.45	+1.01	+10.8	10.7	+2.4
W	7	61 *Geminorum*	DB	3.35	+1.33	.42	− .72	− 9.3	12.9	−3.3
W	7	61 *Geminorum*	RD	+3.35	+1.34	+.42	+ .59	+ 6.4	+10.8	+1.5

* Moon in eclipse.

Minor residuals, mean values. — The values of δM in Table I have been combined by weights into four mean values, at approximately equidistant epochs. The weight of dark limb immersions has been taken to be $4E^2$, of dark limb emersions and bright limb immersions $3E^2$. The results are exhibited in the following table, which includes as well the results of the earlier investigations.

TABLE II

MEAN VALUES OF MINOR RESIDUALS

Mean Epoch	δM	Mean Epoch	δM
1908.58	+3.33	1914.10	+7.29
1909.46	3.64	1914.51	7.68
1910.79	3.72	1915.08	7.33
1911.29	1.49	1915.57	7.88
1912.64	5.81	1916.14	8.10
1913.22	6.96	1916.76	7.54
1913.66	+6.81	1917.45	+8.72

Eclipse of June 8, 1918. — From the curve of minor residuals, δM, extrapolation has been made forward to the date of the coming eclipse. For this date the curve gives

$$\delta M = +8''.1$$

A correction of $\delta M = +1''.9$ has been applied in the *American Ephemeris* computation of the elements of this eclipse. The additional correction to be applied to the mean longitude adopted in the *American Ephemeris* eclipse data is then $+6''.2$, or $+6''.6$ in true longitude. The correction indicated in latitude is $-1''.3$ if, as here seems advisable, we replace NEWCOMB's constant $-0''.3$ with the HANSENIAN constant $-1''.0$. These corrections to the *Moon's* position transform to $+0^s.49$ in right ascension and $-0''.7$ in declination. A correction of $+0^s.10$ is to be applied to the *Sun's* right ascension (see *A. J.*, No. 691). The resulting correction to the time of geocentric conjunction is $-9^s.9$. The correction to the time of total phase is not everywhere the same and this fact is shown below. A slight displacement of the central line is to be noted together with an equal displacement of the northern and southern limiting curves of the path of total phase. The duration of totality requires no correction.

Therefore the results obtained from the eclipse data of the *American Ephemeris* or of the *A. E. Eclipse Supplement* require the corrections tabulated below.

TABLE III

ECLIPSE OF JUNE 8, 1918

Longitude W. from Greenwich	Corrections to *American Ephemeris* values of	
	Time of Totality	Lat. of Central Line
°	s	″
80	− 9.5	+0.20
85	− 9.9	0.24
90	−10.3	0.26
95	−10.7	0.25
100	−11.1	0.22
105	−11.5	0.18
110	−11.9	0.12
115	−12.3	+0.04
120	−12.7	−0.05
125	−13.1	−0.15

Nautical Almanac Office, U. S. Naval Observatory, Feb. 27.

MEASURES OF DOUBLE STARS,

MADE WITH THE 26-INCH REFRACTOR OF THE LEANDER McCORMICK OBSERVATORY,

By CHARLES P. OLIVIER.

This paper contains measures of seventy-two double stars which were made mostly in 1917. The number is smaller than usual due to very long spells of cloudy weather and the consequent necessity for using the telescope in other lines of research. No changes in methods have been made and the micrometer is the same one previously used. The present paper is made up almost entirely of doubles selected from the lists of JONCKHEERE and AITKEN, there being 45 of the former and 15 of the latter, one being a duplicate, J585 = A2303. In addition, the new doubles OL. 55-65 inclusive, are announced. Complete measures have been made for 4 of these, and the other 7 are given in Table II. These will be finally measured as soon as possible. The most interesting discovery of all was, however, that the brighter component of OL 31 was a close double, thus making this a triple system.

As pointed out in my last paper in *A. J.* 714, there was a very large systematic difference between my measures of the JONCKHEERE pairs and those made by their discoverer. This has led to the inclusion of large numbers of his pairs in the present observing list.

Meantime, Vol. LXI of the *Memoirs of the Royal Astronomical Society* has appeared containing the excellent and most important catalogue of recent discoveries of double stars by all observers, prepared by Mr. Jonckheere. This catalogue furnishes a most worthy supplement to Burnham's "General Catalogue," and has been of immense assistance in the recent work here. Since he has therefore printed many new measures of his own pairs, for purposes of comparison, his different measures have been combined, using the number of nights as the weight, which seemed the only fair way since there is little chance of most faint doubles showing motion within a few years. Comparing his angles with my own; in 24 out of 45 cases we agree within 2°, while the average deviation is only 3°.0, and as these deviations have no preference as to sign, my own angles usually confirm his very well.

But the comparison of the distances of the 45 doubles shows that my distances are 0″.31 wider on an average. Ten cases showed less differences than 0″.13. These had in general distances of about 2″ or wider and were about equal in magnitudes. For distances under 1″.2 the residuals were very large; also for wider distances but larger differences in magnitudes. Comparing my distances for the 15 Aitken doubles in this paper, which are in general not unlike the Jonckheere doubles in distance, magnitude, etc., it is found that my measures are on an average 0″.078 wider. Previous similar comparisons of my measures with Dr. Aitken's showed that we differed less than 0″.10, my measures being constantly wider. The conclusion is inevitable, therefore, that the distances of the Jonckheere pairs, as measured by their discoverer, are usually much too small. At the same time I cannot refrain from expressing my admiration that Mr. Jonckheere was able to discover at all, and especially measure, many of his pairs, which are very difficult objects even with our 26-inch refractor, while his work was done with the 14-inch Lille refractor, a far less powerful instrument. It is my plan to remeasure large additional numbers of his doubles in the near future.

In the table the right ascensions and declinations are given for 1920. Immediately after the name of the star appears a number. When in brackets it refers to Jonckheere's new "Catalogue of Double Stars," when unbracketed to Burnham's "General Catalogue." The magnitudes or differences of magnitudes are the means of estimates by the writer. The measures were generally made under favorable conditions of seeing; powers of 560, 700 and 850 were used; and the double was usually near the meridian when observed.

J 143 [**6**] 9.6 — 10.2

R.A. $0^h\ 1^m\ 55^s$ Decl. +12° 49′

	°	″
1917.754	86.9	2.49
17.773	87.8	2.59
1917.764	87.4	2.54

A 1801 [**19**] 9.0 — 9.1

R.A. $0^h\ 5^m\ 51^s$ Decl. +8° 8′

1917.754	191.7	0.56
17.863	190.8	0.61
1917.808	191.2	0.58

J 583 [**55**] 9.2 — 10.2

R.A. $0^h\ 19^m\ 29^s$ Decl. +12° 1′

1917.850	246.9	3.21
17.858	245.7	3.48
1917.854	246.3	3.34

J 631 [**60**] 9.8 — 10.0

R.A. $0^h\ 21^m\ 36^s$ Decl. +3° 47′

1917.715	111.8	3.72
17.880	112.7	3.82
1917.798	112.2	3.77

J 632 [**61**] 9.5 — 9.6

R.A. $0^h\ 21^m\ 51^s$ Decl. +3° 40′

	°	″
1917.715	258.4	1.70
17.880	258.8*	1.66
1917.798	258.6	1.68

J 168 A — B [**69**] 9.1 — 9.2

R.A. $0^h\ 25^m\ 30^s$ Decl. +19° 51′

1917.754	172.2	1.45
17.773	172.0	1.24
17.880	174.1	1.41
1917.802	172.8	1.37

J 168 A — C 9.1 — 11

1917.754	260.7	12.11
17.850	260.9	....
17.880	260.0	12.39
1917.828	260.5	12.25

J 585 [**93**]

R.A. $0^h\ 37^m\ 39^s$ Decl. +17° 25′

1917.754	215.2	1.32
17.773	215.0	...
17.880	214.6	1.39
1917.802	214.9	1.36

J 223 [**109**] 9.4 — 9.5

R.A. $0^h\ 44^m\ 38^s$ Decl. +10° 19′

	°	″
1917.715	98.1	1.56
17.754	97.3	1.55
1917.734	97.7	1.56

J 637 [**124**] 9.5 — 10.7

R.A. $0^h\ 19^m\ 50^s$ Decl. +8° 10′

1917.715	168.1	2.96
.734	171.1	2.90
1917.724	169.6	2.93

A 204 **555** 9.0 — 9.2

R.A. $1^h\ 0^m\ 21^s$ Decl. −2° 29′

1916.858	237.5	1.22
17.880	238.8	1.20
1917.369	238.2	1.21

J 640 [**227**] 9.2 — 9.2

R.A. $1^h\ 28^m\ 50^s$ Decl. +5° 18′

1917.713	225.4	1.63
17.858	223.0	1.61
1917.786	224.2	1.62

A 2216 **[318]** 8.8 — 9.1

R.A. $1^h 57^m 49^s$ Decl. $+11° 48'$

	°	″
1917.754	147.0	1.67
17.880	147.3	1.74
1917.817	147.2	1.70

A 443 **1155** 9.5 — 9.6

R.A. $2^h 9^m 17^s$ Decl. $-3° 52'$

1916.861	134.7	1.28
16.908	136.3	. . .
17.858	132.3	1.17
1917.209	134.4	1.22

J 648 **[373]** 9.1 — 9.4

R.A. $2^h 24^m 48^s$ Decl. $+0° 23'$

1917.713	154.8	2.74
17.893	155.8	2.80
1917.803	155.3	2.77

A 2019 **[377]** 9.0 — 9.3

R.A. $2^h 25^m 45^s$ Decl. $+6° 10'$

1917.713	247.0	1.27
17.850	244.7	1.17
1917.782	245.8	1.22

A 2607 **[309]** 9.2 — 9.4

R.A. $2^h 31^m 34^s$ Decl. $-13° 8'$

1917.713	246.2	1.05
17.880	248.9	1.05
1917.796	247.6	1.05

J 672 **[412]** 9.4 — 9.7

R.A. $2^h 35^m 57^s$ Decl. $+11° 54'$

1916.958	83.6	3.58
16.993	83.6	. . .
17.858	84.7	3.57
1917.270	84.0	3.58

Σ 295 **1386** 4 ±

R.A. $2^h 36^m 6^s$ Decl. $-1° 20'$

1917.858	319.0	4.24
17.880	319.5	4.41
1917.869	319.2	4.32

A 2223 **[429]** 9.0 — 9.2

R.A. $2^h 43^m 27^s$ Decl. $+17° 17'$

1917.850	60.6	1.94
17.880	62.6	1.88
1917.865	61.6	1.91

Ol 55 9.4 — 12

R.A. $2^h 53^m.5$ Decl. $-1° 52'$

	°	″
1917.858	55.2	2.31
17.880	53.5	2.54
1917.869	54.4	2.42

A 2413 **[156]** 8.9 — 9.0

R.A. $2^h 56^m 6^s$ Decl. $+1° 34'$

1916.682	185.1	0.56
17.880	188.5	0.55
1917.281	186.8	0.56

Alden 1 9.4 — 9.6

R.A. $3^h 36^m 56^s$ Decl. $-3° 39'$

1917.713	146.0	1.63
17.844	140.1	1.61
17.855	143.1	1.64
1917.804	143.1	1.63

J 708 **[755]** 9.4 — 9.6

R.A. $4^h 19^m 28^s$ Decl. $-6° 45'$

1917.855	283.9	2.62
17.858	282.9	2.47
1917.856	283.4	2.54

J 709 **[661]** 9.1 — 9.4

R.A. $4^h 25^m 41^s$ Decl. $-3° 45'$

1917.713	88.7	1.45
17.844	88.3	1.62
1917.778	88.5	1.54

J 710 **[681]** 9.4 — 10.7

R.A. $4^h 34^m 19^s$ Decl. $-2° 52'$

1917.855	320.4	2.68
17.858	318.8	2.65
1917.856	319.6	2.66

J 325 **[830]** 9.5 — 10.3

R.A. $5^h 14^m 23^s$ Decl. $-9° 31'$

1917.844	180.3	2.09
17.844	180.5	2.11
17.855	178.7	2.08
1917.848	179.8	2.09

A 2804 **[810]** 9.0 — 9.6

R.A. $5^h 16^m 19^s$ Decl. $-2° 46'$

1917.841	94.9	1.04
17.855	92.4	0.99
1917.850	93.6	1.02

J 329 **[870]** 9.6 — 10.5

R.A. $5^h 22^m 30^s$ Decl. $-0° 2'$

	°	″
1917.844	168.0	2.29
17.855	169.3	2.38
1917.850	168.6	2.34

J 1255 **[888]** 9.5 — 9.6

R.A. $5^h 25^m 30^s$ Decl. $+2° 23'$

1917.844	199.4	1.44
17.855	201.5*	1.52
1917.850	200.4	1.48

J 7 **[893]** 9.4 — 10.0

R.A. $5^h 26^m 16^s$ Decl. $-2° 50'$

1917.844	207.4	1.72
17.855	210.8	1.84
1917.850	209.1	1.78

J 390 **[1125]** 9.2 — 10.0

R.A. $6^h 6^m 19^s$ Decl. $+12° 14'$

1917.855	105.4	1.99
17.970	106.6	1.77
1917.912	106.0	1.88

J 18 **[1137]** 9.6 — 10.1

R.A. $6^h 8^m 39^s$ Decl. $+15° 56'$

1917.855	189.8	1.69
17.970	186.4	1.59
1917.912	188.1	1.64

J 373 **[1643]** 9.0 — 10.4

R.A. $7^h 37^m 25^s$ Decl. $+6° 2'$

1917.105	103.0	1.37
17.855	104.2	1.43
1917.480	103.6	1.40

J 707 **[1663]** 9.5 — 9.6

R.A. $7^h 42^m 16^s$ Decl. $+11° 17'$

1917.855	117.1	2.00
17.970	120.7	1.91
1917.912	118.9	1.96

J 413 **[1670]** 9.3 — 10.4

R.A. $7^h 45^m 49^s$ Decl. $+13° 48'$

1917.855	287.0	2.96
17.970	289.6	2.92
1917.912	288.3	2.94

Ol 60 9.3 — 10.0
R.A. $8^h\ 0^m$ Decl. $+12° 55'$

	°	″
1917.855	107.2	3.77
17.970	109.1	3.73
1917.912	108.2	3.75

Ol 31 ½(A + C) — B 9.2 — 10.1
R.A. $8^h\ 2^m\ 48^s$ Decl. $-22° 37'$

1914.868	356.2	...
14.956	356.2	...
15.912	355.9	3.15
16.902	356.0	3.03
17.844	357.5	3.11
1916.096	356.4	3.10

Ol 31 A — C 9.5 — 9.6

1917.844	167.5	0.80

Ol 32 10.3 — 11.1
R.A. $8^h\ 14^m\ 14^s$ Decl. $-25° 22'$

1917.844	299.8	1.49
17.970	299.8	1.54
1917.907	299.8	1.52

J 735 **[1826]**
R.A. $8^h\ 41^m\ 52^s$ Decl. $+8° 6'$

1917.844	337.0	2.52
17.855	334.8	2.46
1917.850	335.9	2.49

A 29.. **[1859]** 9.0 — 9.2
R.A. $8^h\ 52^m\ 46^s$ Decl. $+11° 5'$

1917.855	133.8	1.22
17.970	134.9	1.21
1917.912	134.4	1.22

A 1760 **[1907]** 8.2 — 11
R.A. $9^h\ 11^m\ 27^s$ Decl. $-0° 44'$

1917.296	142.6	1.77
17.970	141.6	1.75
1917.633	142.1	1.76

J 386 **[1909]** 0.1
R.A. $9^h\ 18^m\ 45^s$ Decl. $+10° 29'$

1917.296	208.6	1.28
17.970	207.1	1.27
1917.633	207.8	1.28

A 2483 **[2050]** 9.0 — 10.6
R.A. $10^h\ 37^m\ 52^s$ Decl. $+16° 42'$

	°	″
1917.302	224.2	1.87
17.970	222.2	1.80
1917.636	223.2	1.84

J 82 **[2095]** 0.4
R.A. $11^h\ 5^m\ 50^s$ Decl. $+11° 20'$

1917.031	112.8	1.96
17.080	109.1	2.10
17.244	108.0	2.08
1917.118	111.0	2.05

β 28 **6185** 3 ±
R.A. $12^h\ 25^m\ 57^s$ Decl. $-12° 57'$

1915.042	24.8	1.54
17.080	24.2	...
17.296	26.7	1.52
1916.473	25.2	1.53

Lv 5 **6208** 1.8
R.A. $12^h\ 29^m\ 58^s$ Decl. $-17° 45'$

1915.042	18.3	1.32
17.296	20.4	1.42
1916.169	19.4	1.37

A 1785 **[2225]** 8.9 — 10.7
R.A. $13^h\ 1^m\ 45^s$ Decl. $+9° 30'$

1917.294	124.4	1.79
17.296	127.1	1.93
17.302	127.8	1.84
1917.297	126.4	1.85

A 1788 **[2251]** 9 — 10.9
R.A. $13^h\ 20^m\ 32^s$ Decl. $+15° 39'$

1917.296	149.5	2.09
17.302	149.1	2.17
1917.299	149.3	2.13

Hu 663 **[7650]** 9.0 — 10.9
R.A. $16^h\ 25^m\ 59^s$ Decl. $+51° 46'$

1917.080	222.5	3.58
17.094	221.3	3.67
17.302	221.2	3.93
1917.159	221.7	3.73

This star shows a large difference from H's measures in 1903, probably due to proper motion.

Hu 667 **10035** 9.7 — 9.9
R.A. $18^h\ 56^m\ 31^s$ Decl. $+12° 58'$

	°	″
1917.715	41.4	1.57
17.735	40.2	1.62
1917.725	40.8	1.60

J 813 **[2802]** 9.8 — 10.1
R.A. $19^h\ 4^m\ 14^s$ Decl. $+9° 25'$

1917.715	11.2	1.29
17.735	8.7	1.33
1917.725	10.0	1.31

Ol 63 9.7 — 10.7
R.A. $19^h\ 7^m\ 39^s$ Decl. $+9° 27'$

1917.715	62.8	1.39
17.735	65.2	1.60
1917.725	64.0	1.50

J 1304 **[2885]** 9.6 — 9.8
R.A. $19^h\ 21^m\ 0^s$ Decl. $+11° 27'$

1917.715	60.1	1.96
17.781	57.3	1.96
1917.748	58.7	1.96

Ol 64 10.1 — 10.6
R.A. $19^h\ 27^m\ 9^s$ Decl. $+11° 27'$

1917.715	267.1	1.38
17.735	262.7	1.28
1917.725	264.9	1.33

J 577 **[3484]**
R.A. $21^h\ 9^m\ 16^s$ Decl. $+17° 42'$

1917.715	22.6	2.41
17.735	21.3	2.26
1917.725	22.0	2.34

J 197 **[3534]** 9.1 — 9.2
R.A. $21^h\ 25^m\ 26^s$ Decl. $+14° 30'$

1917.773	23.3	2.83
17.880	24.7	2.94
1917.826	24.0	2.88

J 178 **[3540]** 9.5 — 10.4
R.A. $21^h\ 27^m\ 2^s$ Decl. $+11° 20'$

1917.773	184.1	2.64
17.880	187.4	2.85
1917.826	155.8	2.74

J 200 **[3552]** 9.6 — 9.7
R.A. $21^h 30^m 36^s$ Decl. +14° 54′

	°	
1917.773	135.4	2.90
17.880	133.6	2.79
1917.826	134.5	2.84

J 285 **[3551]** 9.8 — 9.9
R.A. $21^h 30^m 59^s$ Decl. +15° 30′

1917.773	77.2	2.10
17.880	74.7	2.40
1917.826	76.0	2.10

J 617 **[3737]** 9.0 — 9.1
R.A. $22^h 29^m 47^s$ Decl. +21° 52′

1917.754	108.2	1.05
17.858	105.0	1.00
1917.806	106.6	1.02

J 292 **[3710]** 9.0 — 10.2
R.A. $22^h 30^m 33^s$ Decl. +13° 35′

1917.754	46.1	2.32
17.858	47.4	2.18
1917.806	46.8	2.25

J 165 **[3753]** 9.0 — 9.3
R.A. $22^h 33^m 56^s$ Decl. +11° 6′

1917.754	135.5	2.06
17.858	134.7	2.08
1917.806	135.1	2.07

J 618 **[3759]** 10.1 — 10.3
R.A. $22^h 36^m 44^s$ Decl. +16° 9′

	°	″
1917.754	226.8	1.79
17.858	229.4	1.85
1917.806	228.1	1.82

J 668 **[3786]** 9.2 — 9.6
R.A. $22^h 49^m 44^s$ Decl. +7° 57′

1917.754	323.9	2.17
17.858	320.7	2.18
1917.806	322.3	2.18

Vand 2 **[3789]** 9.3 — 9.4
R.A. $22^h 50^m 25^s$ Decl. +7° 58′

1917.754	130.7	3.46
17.858	130.4	3.40
1917.806	130.6	3.43

J 669 **[3795]** 10.4 — 10.6
R.A. $22^h 53^m 10^s$ Decl. +13° 38′

1917.754	36.7	1.27
17.858	37.1	1.21
1917.806	36.9	1.24

J 670 **[3825]** 9.2 — 10.3
R.A. $23^h 8^m 0^s$ Decl. +8° 26′

1917.773	190.4	1.83
17.880	193.0	2.03
1917.826	191.7	1.93

J 581 **[3837]** 8.9 — 9.0
R.A. $23^h 11^m 54^s$ Decl. +14° 2′

	°	″
1917.773	18.5	1.35
17.880	17.0	1.45
1917.826	17.8	1.40

Hu 1325 **[3897]** 8.7 — 10.2
R.A. $23^h 36^m 3^s$ Decl. +12° 32′

1917.754	189.1	0.52
17.858	188.0	0.56
1917.806	188.6	0.54

J 300 **[3912]** 9.2 — 9.5
R.A. $23^h 43^m 6^s$ Decl. +15° 48′

1917.850	8.5	3.60
17.880	9.0	3.56
1917.865	8.8	3.58

Hu 1327 **[3923]** 8.7 — 9.0
R.A. $23^h 48^m 24^s$ Decl. +12° 26′

1917.754	31.2	1.54
17.773	31.4	1.63
1917.764	31.3	1.58

J 215 **[3943]** 9.4 — 11.9
R.A. $23^h 57^m 32^s$ Decl. +16° 32′

1917.773	36.7	2.57
17.880	36.9	2.66
1917.826	36.8	2.62

TABLE II

ADDITIONAL NEW DOUBLES.

	h m s	° ′	°	″	M M
OL 56	5 21 ..	− 0 4	116	2.4	9.9 — 10.9
OL 57	5 34 ..	− 4 55	20	0.7	10.0 — 10.3
OL 58	7 41 14	−19 7	115	1.3	9.7 — 10.6
OL 59	7 44 ..	+11 16	17	2.5	9.9 — 11.3
OL 61	8 6 ..	−25 19	176	1.4	10 — 11
OL 62	8 27 ..	−19 29	189	0.5	9.5 — 9.7
OL 65	22 15 ..	+52 45	226	3.5	9.2 — 12

University of Virginia, 1918, February 25.

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ADDITIONAL CORRECTIONS TO THE *MOON'S* MEAN LONGITUDE

FROM

AN INVESTIGATION OF THE MINOR RESIDUALS OF NEWCOMB'S EMPIRICAL TERM OF 275 YEARS EXTENDING OVER A PERIOD OF 65 YEARS.

By E. B. TUSTIN, Jr.

(A supplement to "Researches on the Motion of the *Moon*," Vol. IX, Part I; papers of the *American Ephemeris* and *Nautical Almanac*. Page numbers in the present work refer to NEWCOMB's papers.)

In view of the desirability of predicting the eclipse, June 8, 1918, with all the accuracy possible, and the inaccuracies in the present Lunar Ephemeris, the following paper may be of interest.

An inspection of the outstanding residuals of NEWCOMB's empirical term of 275 years (p. 211) shows their distribution to be of such a marked systematic character that it was considered expedient to assume them the sum of functions of the time, deriving from them as well as from more recent observations empirical formula with the expectation of thus having the *Moon's* motion represented for a future term of years with all the precision possible.

The residuals may accordingly be written in the form:

$$r = f_1(t) + f_2(t) + \dots\dots f_j(t).$$

The functions involve the time in an unknown manner because the *Moon's* longitude is subject to fluctuations which cannot as yet be expressed by any known formula, preventing the solution of these equations in their entirety.

Therefore a thorough discussion of the residuals is unnecessary, since nothing is known of the law or cause of the fluctuations. The labor can then be greatly diminished by deriving only approximate results, which are as good as the best until the unknown law is discovered.

In view of these facts it was decided to represent the residuals as the sum of a series of periodic terms. The residuals cannot be advantageously expressed by the usual trigonometric series because of the large number of terms and the unknown fundamental argument. This being impracticable it was decided to let each annual residual group furnish one equation of condition, the number of terms taken to be such that the residuals will, in the solution, be as well represented as need be, yet as few in number as will give the requisite accuracy.

Finally it was decided that if the mean error of the deduced formulæ was within the limits of error of the residuals, it would have all the requisite accuracy.

METHODS OF REDUCTION

The occultations are reduced by the method given on page 20, with the slight modification of subtracting from $(s' - D)$ the effect of the latitude correction on the ecliptic longitude, the mean of the HANSENIAN and NEWCOMB constants $(-0''.7)$ being used:

$$\cos m' \,[+0''.7 + 0''.09\,(v - \Omega)\,\Delta v_0],$$

where v_0 is the approximate longitude correction, v the longitude of the *Moon*, and ☊ the longitude of its node.

The deviation of the mean longitude from pure theory is then obtained:

$$\text{Dev. theory} = \frac{\Delta v - (dl + h + k)}{F}\begin{array}{l}\text{p. 46}\\ \text{p. 25}\end{array} - (\underset{210,}{N_2} + \underset{203.}{Th}).$$

The minor residuals are finally gotten by further subtracting NEWCOMB's empirical term of long period, (p. 210).

Data Used

Date	Annual Residual Group r.	p. e.	Authority
1853.5 — 1908.3	(+3″.9 to −3″.5)	1″.0	p. 211. (Extreme range of values given in parenthesis.)
1909.5	+3.6		*Astronomical Journal*, Dr. F. E. Ross.
1910.8	3.7		*Astronomical Journal*.
1911.3	4.5		*Astronomical Journal*.
1912.6	5.8		*Astronomical Journal*.
1913.4	6.9		*Astronomical Journal*.
1914.5	7.2	0 .9	Wtd. mean 9; central dark limb; im. and em. evenly distributed; Naval Observatory, June, July, August.
1915.5	7.4	0 .8	Ditto, 9 occs.
1916.8	+7.6	0 .8	Ditto, 12 occs. Sept., Oct., Nov.

The individual residuals composing the 1914.5, 1915.5, 1916.8 groups were deduced by the writer.

Assignment of Weights

Newcomb's assumption of a possible error of 1″.0 of each decennial mean result composing his empirical term of 275 years, lead me to assume each residual of this term to be affected with a possible error of that magnitude. Therefore the weights assigned to the equations corresponding to the annual groups (1853.5 — 1908.3) are unity.

The weights of the 1909.5 — 1916.8 groups were made two; the acceptance of this weight being justified by the fact that the end at which we are practically aiming is that of predicting the *Moon's* motion during the next decade, and that can be probably best done by making our empirical theory fit as well as possible into the most modern observations.

Preliminary Solution

A rough least-square solution showed the actual residual curve to be fairly well represented by the assumed terms:

$$c_0 + c_1 \sin (A_1 + 6^\circ.2t) + c_2 \sin (A_2 + 7^\circ.7t),$$

using in this first approximation the above rough assumed values of the annual motion of the arguments.

Upon plotting these terms, after their coefficients were determined, a second approximation to the fundamental argument was made $5^\circ.7t$, by the comparison of dates and corresponding ordinates of these terms with the actual residual curve.

A third term with an argument three times the fundamental was added afterwards, as additional inspection of the actual residual curve made desirable. Its coefficient may conceivably represent nearly the effect of the periodic sun-spot maximums, in a term, the existence of which E. W. Brown has hinted at, his supposed value of its coefficient (0″.5) being surprisingly in accord with my deduced value.

Second Approximation

The annual minor residual groups are now expressed in the form:

$$r = c_0 + c_1 \sin (A_1 + 5^\circ.7t) + c_2 \sin (A_2 + B5^\circ.7t) + c_3 \sin [A_3 + 3\,(5^\circ.7t)]\,,$$

the date 1850.5 taken as the epoch.

Since the unknown quantity B of the second term does not enter in a linear form, the easiest course is to find by trial what value of this quantity will lead to the best solution. I have actually assumed the following three values of B:

$$B = 1^\circ.2,\ 1^\circ.3,\ 1^\circ.4.$$

To effect the solution we make a transformation of the terms by introducing the auxiliaries x_j and y_j. In the following expression K_j represents the annual motion of the arguments:

$$\begin{aligned} c_j \sin (A_j + K_j t) &= x_j \sin K_j t + y_j \cos K_j t\,, \\ x_j &= c_j \cos A_j\,, \\ y_j &= c_j \sin A_j\,, \\ x_0 &= c_0\,. \end{aligned}$$

In order to shorten this paper I have omitted exhibiting, numerically, the large number of equations of condition and the normal equations resulting.

The results obtained from a solution of the normal equations are exhibited in the following table:

$B =$	1°.2	1°.3	1°.4
	″	″	″
x_0	+1.128	+1.025	+0.869
x_1	+0.237	+0.794	+1.004
y_1	+8.075	+6.354	+5.191
x_2	−1.687	−2.026	−1.752
y_2	−4.520	−2.441	−1.189
x_3	−0.1787	−0.1869	−0.1860
y_3	−0.4650	−0.4539	−0.3907
(pvv)	36.15	36.42	41.59

$$(nn) = (rr) = 565''.36$$

We deduce from the above table (pvv) a minimum for $B = 1.242$. The values of the elements corresponding are:

$$\begin{aligned} &x_0 + 1''.091 \\ &x_1 + 0.513 \\ &y_1 + 7.285 \\ &x_2 - 1.903 \\ &y_2 - 3.548 \\ &x_3 - 0.1832 \\ &y_3 - 0.4666. \end{aligned}$$

The empirical terms are accordingly:

$$\begin{aligned} r = 1''.09 &+ 7''.30 \sin (86° + 5°.7t) \\ &+ 4''.03 \sin (242° + 7°.1t) + 0''.50 \sin (249° + 17°.1t). \end{aligned}$$

$$m.\,e. = 0''.83, \qquad t = (T - 1850.5).$$

This mean error being within the limits of the possible error assigned to the minor residual groups, a third approximation using a different value for the fundamental argument is unnecessary. The above expression is thus adopted as representing within limits of possible error the minor residual groups of NEWCOMB'S empirical term of long period during the period 1853.5 — 1916.8.

CORRECTIONS TO THE BESSELIAN ECLIPSE ELEMENTS, JUNE 8, 1918

The deduced terms give, for June 8, 1918:

$$r = +7''.8$$

A correction, $r = +1''.9$, has been applied to the *Moon's* mean longitude used in the *American Ephemeris* eclipse elements. Therefore the additional correction to be applied is $+5''.9$, $= +6''.3$ in true longitude, or $+0^s.47$ in R. A. The correction in latitude is $-1''.6$, or $-1''.0$ in Decl., using the mean of the HANSENIAN and NEWCOMB constants, $(-0''.7)$.

The correction to be applied to the *Sun's* true longitude, June 8, 1918, is $+1''.4$, or $+0^s.10$ in R. A. (*A. J.*, No. 691).

The resulting corrections to be applied to the Besselian elements given in the *American Ephemeris* or *American Ephemeris Eclipse Supplement* are therefore:

$$dx = +0.00145, \qquad dy = -0.00028,$$

these corrections to the coördinates being constant to the fifth place during the eclipse.

Carlisle, Penna., March, 1917.

THE ORBIT OF Σ 1879 = B 6999.

BY GEORGE C. COMSTOCK.

An orbit of this binary star has been determined by VAN BIESBROECK (*Annales * * *, Belgique* IX, I, p.118), from observations included between the epochs 1827 – 1904 and the author in presenting his results very justly remarks that the elements are uncertain because of lack of data in the critical period, about 1865, within which the companion passed through its periastron. Since the motion of the star subsequent to 1904 shows rather large and systematic deviations from VAN BIESBROECK'S ephemeris, I have made a redetermination of the orbit based upon a considerable amount of additional data, having in view a threefold purpose, (*a*) Improvement of the elements, (*b*) Examination of the motion for possible irregularities such as might arise from the presence of a disturbing body, (*c*) A study of the precision of measurement attained by the principal double star observers and the consistency of their results *inter se*. Conclusions in this last matter must, of course, be based upon an examination of many stars and the present article can furnish only an installment of such a programme.

The material utilized in the present case is shown in the following Table I, whose several columns are sufficiently explained by their headings, save that the bracketed values in the column of Distances Observed are computed quantities introduced here for comparison only.

With the time as abscissa I have plotted upon a fairly large scale the observed position angles, θ, (reduced to 1900.0) and the observed distances, s, and have drawn smooth curves through the plotted points. From these curves I have found the values of the apparent double areal velocity, $s^2 d\theta/dt$, and have plotted these values as ordinates to the time as abscissas. The plotted points are so nearly represented by a straight line parallel to the time axis that I find no occasion to assume any disturbance in the motion. I have therefore adjusted the θ and s curves originally drawn, so that they shall furnish constant values of $s^2 d\theta/dt$ and I adopt these curves as a graphical adjustment of the observations.

Between the years 1851 – 1877 there is an almost complete lack of observations and the curves are therefore not well determined here. They are, however, even in this period far from being a matter of arbitrary choice, since they must everywhere present a smooth and flowing course that satisfies the constant areal velocity, elsewhere found, and at each end of the period in question they must constitute a smooth continuation of the parts of the curve based upon direct observation. Furthermore, a superior limit to the minimum distance between the stars is unequivocally fixed by the total change in the ordinates of the curve during the period in which observations are missing. In the present case the total change of position angle, 200°, in the interval between 1850 and 1877, and the well determined double areal velocity, 0″.52 per annum, show that at some time during this period the distance between the stars was less than 0″.27. The curves as drawn give as this minimum distance 0″.16.

From the adopted θ and s curves I have read, at five year intervals, values of the coördinates to be used as normal places in the determination of elements of an orbit, and by a graphical process I have derived from these data provisional elements, C, I, that do not differ greatly from those of VAN BIESBROECK, viz.:

	VAN B.	C, I	C, II	
	°		°	
☊	74.1	54.1	53.4	
i	57.6	56.2	60.4	1900.0
ω	208.6	229.4	228.6	
e	0.70	0.80	0.778	
a	1.06	1.00	1.10	
T	1868.3	1871.2	1871.0	
P	238	232	240	
n	1°.51	1°.55	1°.50	

From the elements C, I, I have computed an ephemeris and compared with it all of the observations shown in Table II. The resulting residuals indicate by their systematic character the possibility of improving the elements employed and I have therefore found by the methods set forth in *Astr. Jour.*, No. 725, equations for their correction. These, however, proved inadequate for a complete determination of the orbit. Within rather wide limits arbitrary values may be assigned to certain elements and the others so determined as to satisfy the observed data; *e.g.*, an erroneous value of the periodic time may be very well compensated by a properly chosen eccentricity, etc. The equations seem adequate to determine four unknown quantities and no more, and for these four I have somewhat arbitrarily chosen, ☊, i, e, and a, and have assigned to ω, T_0 and n values slightly simplified but not essentially different from those given under C, I. These values together with those resulting from a least-square solution of the modified observation equations are shown above under the heading C, II. A comparison of the observations with the positions furnished by these elements is given in Table I. The adopted elements ☊, i, e are based upon all the observations of position angle; the major axis, a, is derived from the distance observations subsequent to 1877; the earlier data being ignored as hopelessly discordant. The residuals of Table I tend to justify STRUVE's observations and to throw upon MAEDLER and GLAISHER responsibility for the discordances.

The representation of the data through the residuals shown in Table II is in general satisfactory as regards magnitude, although there exists a certain tendency toward permanence of sign in the decade 1890 – 1900, that I have not been able to improve by further change in the elements. In so far as it is real this permanence of sign may be regarded as arising from and measuring the effect of, (a) error in the adopted orbit, (b) systematic error in the observations, (c) physical disturbance of the star's motion. If we ignore the effects thus arising and derive from the residuals the probable error of an observation equation, this quantity, in so far as it is not a proper measure of the precision of the data, will tend to underestimate that precision and to err on the safe side in any conclusions that may be drawn from it. I have derived such an average probable error as follows. Ignoring differences of quality in the work of different observers, I have assigned to each residual shown in Table II a weight based solely upon the number of nights observing entering into the residual, in accordance with the following scheme of weights:

Nights	1	2	3	4	More
Weight	1	2	2	2	3

I find the following probable errors of an equation of unit weight, *i. e.*, a single observation, and of an equation of average weight, *i. e.*, mean of three nights:

	In Angle	In Distance
One observation	±0″.028	±0″.044
An average equation	±0″.020	±0″.031

In deriving the probable error in distance I have omitted the two residuals furnished by MAEDLER, since I have shown in *Astr. Jour.*, No. 712, that his observations of distance are there affected by very unusual systematic errors agreeing in magnitude and sign with the residuals here found. No other residual has been rejected.

The material under consideration can contribute little to a study of the systematic errors of individual observers since it contains few extended series of observations made by the same person. Nevertheless, I have collected and united into mean values the residuals furnished by each astronomer for whom five or more annual mean results are available. These means and the number of years observing, n, upon which they are based are shown in the following Table I. The probable error appended to each mean is obtained by dividing by $\sqrt{n}$ the probable error of an average result above found.

TABLE I.

SYSTEMATIC ERROR.

Observer	n	C — O In Position-Angle		C — O In Distance	
		″	″	″	″
SCHIAPARELLI	16	+0.01	±0.005	−0.01	±0.008
LEWIS	5	+ .03	.009	+ .05	.014
COMSTOCK	14	.00	.005	.00	.008
VAN BIESBROECK	7	− .02	.008	− .02	.012

Despite the small amount of data it would seem from these numbers that the systematic differences of a personal character affecting the work of these observers must, in the present case, be very small, certainly not exceeding a fraction of a tenth of a second. Combining this result with the average precision of the observing as shown above, we may infer that in cases similar to the present one, persistent residuals whose magnitude is of the order 0″.1 are to be explained as the result of physical rather than psychological causes. I believe this principle to be generally applicable in double star work and that in general the limiting value above given, 0″.1, errs on the side of conservatism. In the present case the persistent residuals are so much below the suggested limit as to render doubtful their real character.

To facilitate comparison of the orbit here found with other observations the following brief ephemeris is given.

EPHEMERIS. EL. C, II.

	°		″	
1910.0	124.6		0.64	
		5.9		6
15.	118.7		.70	
		4.9		7
20.	113.8		.77	
		4.1		6
25.	109.7		.83	
		3.5		6
30.	106.2		.89	
		3.2		7
35.	103.0		.96	

TABLE II.

COMPARISON OF THE OBSERVATIONS WITH ELEMENTS C, II.

Date	Obs'r	n	Position Angle Obs.	Position Angle O — C		Distance Obs.	Distance O — C
			°	°	″		″
1827.80	Σ	2	67.8	+ 4.1	+0.09	1.17	−0.09
34.39	Σ	1	66.3	+ 5.1	+ .10	1.21	+ .10
42.75	MA.	3	57.9	+ 0.5	+ .01	0.73	− .29
42.79	GLAIS.	3	52.7	− 4.7	− .08	0.82	− .19
51.40	MA.	1	43.5	− 8.3	− .11	0.45	− .36
63.51	Δ	1	Single	.....	.....	[0.35]	.....
65.31	Δ	1	±45	.....	.....	[0.25]	.....
67.32	WINL.	1	18.6	.....	.....	[0.18]	.....
69.39	DUN.	2	Round	.....	.....	[0.17]	.....
77.40	β	1	210.	− 3.5	− .02	0.42	+0.08
77.44	SP.	3	219.1	+ 5.6	+ .03	0.37	+ .03
77.46	Δ	1	222.9	+ 9.4	+ .05	0.34	.00
78.39	Δ	2	206.6	− 2.7	− .02	0.38	+ .04
78.44	β	1	217.1	+ 8.0	+ .05	0.42	+ .08
82.50	SP.	3	183.5	− 8.9	− .05	0.35	−0.02

Date	Obs'r	n	Position Angle			Distance	
			Obs.	O−C		Obs.	O−C
			°	°	″	″	″
1883.47	Sp.	6	177.9	−10.7	−0.07	0.38	0.00
83.55	Eng'l.	7	209.4	+21.0	+ .14	0.31	− .07
84.50	Sp.	2	187.3	+ 2.5	+ .02	0.37	− .01
85.48	Sp.	4	179.5	− 1.6	− .01	0.41	+ .02
86.51	Sp.	4	174.2	− 3.4	− .02	0.45	+ .06
87.44	Hall	3	173.1	− 1.3	− .01	0.38	− .02
87.49	Sp.	4	173.1	− 1.3	− .01	0.40	.00
88.53	Sp.	4	171.6	+ 0.6	+ .00	0.39	− .01
89.50	Sp.	5	166.2	− 1.5	− .01	0.44	+ .03
89.78	HΣ	3	163.2	− 3.6	− .03	0.37	− .04
92.09	Sp.	3	156.2	− 3.7	− .03	0.46	+ .03
93.47	Sp.	5	154.9	− 1.1	− .01	0.45	.00
94.48	Sp.	4	153.4	− 0.1	.00	0.46	+ .01
95.47	Sp.	4	146.1	− 4.9	− .04	0.49	+ .02
96.00	Lewis	5	144.7	− 5.0	− .04	0.45	− .02
97.45	Sp.	6	144.8	− 1.6	− .01	0.47	− .02
97.48	C.	2	143.2	− 3.1	− .03	0.50	+ .01
97.98	Lewis	7	139.8	− 5.4	− .05	0.43	− .06
98.11	Bow.	4	135.0	−10.0	− .08	0.55	+ .06
98.17	A.	3	145.8	+ 0.8	+ .01	0.69	+ .20
98.25	Doo.	3	145.4	+ 0.7	+ .01	0.58	+ .09
98.49	Sp.	4	141.7	− 2.4	− .02	0.46	− .03
99.40	Sp.	5	140.6	− 1.6	− .01	0.50	.00
99.53	C.	3	141.6	− 0.4	− .00	0.57	+ .07
1900.41	Doo.	3	136.5	− 3.7	− .03	0.64	+ .12
00.42	Lewis	4	137.7	− 2.5	− .02	0.48	− .04
01.46	C.	1	139.4	+ 1.3	+ .01	0.47	− .06
02.55	C.	3	131.9	− 4.2	− .04	0.54	− .01
02.84	Lewis	2	132.2	− 3.4	− .03	0.49	− .06
02.97	Bow.	2	129.4	− 5.9	− .05	0.57	+ .02
03.37	C.	3	134.2	− 0.6	− .01	0.51	− .04
03.12	Bry.	1	140.2	+ 5.6	+ .05	0.53	− .02
03.18	Bies.	3	137.0	+ 2.5	+ .03	0.57	+ .02
05.41	A.	2	131.2	− 0.1	− .00	0.60	+ .02
05.87	C.	3	131.4	+ 0.9	+ .01	0.54	− .05
07.35	Bies.	2	131.8	+ 3.5	+ .04	0.64	+ .04
07.58	C.	2	126.2	− 1.7	− .02	0.67	+ .06
07.71	Doo.	4	125.4	− 2.3	− .02	0.68	+ .07
08.28	Bies.	4	126.5	− 0.4	− .00	0.61	.00
08.41	Doo.	4	127.4	+ 0.7	+ .01	0.64	+ .02
08.49	C.	2	126.6	0.0	.00	0.63	+ .01
09.40	Bies.	4	127.1	+ 1.7	+ .02	0.65	+ .02
09.42	C.	2	125.0	− 0.4	.00	0.66	+ .03
09.43	Lewis	1	122.4	− 3.0	− .03	0.56	− .07
09.50	Bry.	3	119.1	− 6.2	− .07	0.54	− .09
10.39	Wirtz	2	125.5	+ 1.4	+ .01	0.68	+ .04
10.43	Fox	3	124.3	+ 0.2	.00	0.63	− .01
10.43	Bry.	2	124.8	+ 0.7	+ .01	0.61	− .03
1910.53	C.	2	123.7	− 0.2	−0.00	0.59	−0.05

Date	Obs'r	n	Position Angle			Distance	
			Obs.	O − C		Obs.	O − C
			°	°	″	″	″
1910.56	Bies.	3	126.8	+ 2.9	+0.03	0.69	+0.05
11.39	Bies.	3	124.0	+ 1.1	+ .01	0.60	− .05
11.41	Bry.	2	122.5	− 0.4	− .00	0.73	+ .08
12.21	A.	1	123.9	+ 2.0	+ .02	0.72	+ .06
12.35	Bow.	2	119.1	− 2.6	− .03	0.79	+ .13
12.43	Bies.	3	122.4	+ 0.8	+ .01	0.73	+ .06
12.45	Bry.	2	121.9	+ 0.3	+ .00	0.68	+ .01
12.49	C.	2	119.6	− 1.9	− .02	0.74	+ .07
13.55	C.	2	120.2	− 0.1	− .00	0.73	+ .05
14.47	C.	2	120.0	+ 0.7	+ .01	0.72	+ .03
16.40	C.	3	118.8	+ 1.6	+ .02	0.65	− .07
1917.36	C.	3	118.8	+ 2.5	+0.03	0.64	−0.09

Washburn Observatory, February, 1918.

FAINT COMPANIONS TO THREE VARIABLE STARS.

By J. A. Parkhurst.

The following variable stars in the fields selected for the establishment of visual standards for faint stellar magnitude, have companions sufficiently faint and close to escape detection unless the variable is faint, but bright enough to affect the estimates when the variable is near minimum.

			α 1900	δ 1900
			h m s	° ′ ″
V Cancri	*A.G. Berlin A*	3295	8 16 1.18	+17 36 8.1
W Herculis	*A.G. Lund*	6805	16 31 40.25	+37 33 1.2
R Lacertæ	*A.G. Bonn*	17038	22 38 49.19	+41 50 42.7

The detailed results will shortly appear in *Publications of the Yerkes Observatory*, Vol. IV, Part 3, but in the mean time the following data may be useful.

Star	Positions			Magnitudes					Min. of Var.
	Pos. Ang.	Dist.	Meas. by	Date	Mag.	Date	Mag.	Mean Mag.	
	°	″		y m d	M	y m d	M	M	M
V Cancri	270	9.62	v B	02 2 11	13.01	02 3 5	13.10	13.06	12.8
W Herculis	331	6.4	P	04 6 10	....	15 3 8	....	13.5	13.9
R Lacertæ	50	5.70	v B	05 8 22	14.03	05 9 4	14.13	14.08	13.9

None of these stars is given as double in Burnham's *General Catalogue* (1906) or Jonckheere's supplementary list (1916), possibly on account of the distance of the faint companions. Professor van Biesbroeck kindly measured the positions of the first and last with the 40-inch refractor, and the second was measured by the writer on two negatives taken with the 2-foot reflecting telescope. The magnitudes of the first and last were measured in the same manner as the standard stars, though with less precision on account of the closeness to the variable; while that of the second is photographic, measured on the negatives.

Yerkes Observatory, March, 1918.

THE POSITION OF THE *MOON* AT THE ECLIPSE OF 1918, JUNE 8,

By ERNEST W. BROWN.

In No. 716 of the *Astronomical Journal*, I gave the correction to the place of the *Moon* at the eclipse of 1918, June 8, based on the supposition that the error of the mean longitude of the *Moon* at that date would be 7″. This "error" is the difference between the mean longitude, based on my theory and the actual mean longitude at the date. The corresponding errors of the true longitude and the latitude to the computed place of the *Moon* as given in the eclipse predictions of the *American Ephemeris* were found to be +6″.9 and −1″.2, respectively. Owing to the courtesy of the Astronomer Royal, I have received the approximate mean error in right ascension of the Greenwich observations of the *Moon* for the year 1917. It indicates that the error in longitude in 1918 will be very near that assumed previously.

In No. 733, Mr. Arthur Newton gives as the probable errors deduced from occultations during the last three years, +7″.2 and −1″.3. For all practical purposes these may be considered the same as those which I deduced earlier. Hence the corrections given in Table III at the end of Mr. Newton's paper to the time of totality and the latitude of the central line are furnished from two sources which both observatorially and theoretically are independent of one another. It is to be hoped that sufficiently good observations of the time and position of the *Moon* at totality will be made so that the data furnished by these predictions may be tested.

Yale University, 1918, May 8.

PARALLAX OF BARNARD'S PROPER-MOTION STAR.

By LUELLA E. SAYER.

The following values of parallax and proper-motion have been determined from ten plates, covering a period of three hundred and fifty-seven days, taken with the eighteen and one-half inch telescope at the Dearborn Observatory.

$$\pi = +0''.557 \pm 0''.016$$

$$\mu_a = -0''.621 \pm 0''.038$$

Dearborn Observatory, April 17, 1918.

CORRECTION TO ARTICLE "THE *MOON*'S MEAN LONGITUDE," *A. J.*, No. 733.

In the last table (p. 100), corrections to *American Ephemeris* values of Latitude of Central Line should be hundredths of a minute of arc and not hundredths of a second.

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Additional Corrections to the *Moon's* Mean Longitude, by E. B. Tustin, Jr.
The Orbit of Σ 1879 = *B* 6999, by George C. Comstock.
Faint Companion to Three Variable Stars, by J. A. Parkhurst.
The Position of the *Moon* at the Eclipse of 1918, June 8, by E. W. Brown.
Parallax of Barnard's Proper-Motion Star, by Luella E. Sayer.
Correction to Article "The *Moon's* Mean Longitude . . ." *A. J.*, No. 733.

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LIBR
JUN 8 1918
UNIVERSITY OF

MEASURES OF DOUBLE STARS,

MADE AT THE LILLE OBSERVATORY AND AT THE ROYAL OBSERVATORY, GREENWICH,

By ROBERT JONCKHEERE.

The following measures are a continuation of the results published in the *Astronomical Journal*, No. 721. In addition to the observations made at Lille and Greenwich, there are a few measures obtained at the Strasbourg Observatory in 1908.

4043 OΣ 171 7h 21m 32s +31° 47′

1900 +	θ °	ρ ″	Mags.		Aper. in.	Rem.
16.320	127.0	1.01	7.0	11.0	28	
17.348	127.0	1.03	7.3	10.0	28	
16.83	127.0	1.02	7.2	10.5	2*n*	(1)

4122 Σ 1110 7h 29m 31s +32° 4′

1900 +	θ °	ρ ″	Mags.		Aper. in.	Rem.
11.165	220.0	5.26	2.5	3.5	14	
11.187	220.9	5.25	3.0	4.0	14	
17.318	219.0	5.03	2.0	3.0	28	
17.329	219.0	5.43	2.0	3.0	28	
17.331	218.0	5.09	2.0	3.0	28	
11.18	220.5	5.26	2.7	3.7	2*n*	(2)
17.33	218.7	5.18	2.0	3.0	3*n*	

5071 Σ 1348 9h 20m 17s +6° 42′

1900 +	θ °	ρ ″	Mags.		Aper. in.	Rem.
15.353	316.8	1.85	7.3	7.3	28	
17.348	323.0	1.65	7.0	7.3	28	
16.35	319.9	1.75	7.2	7.3	2*n*	(3)

5397 Σ 1426 10h 16m 20s +6° 50′

A and *B*

1900 +	θ °	ρ ″	Mags.		Aper. in.	Rem.
15.353	291.6	0.72	7.5	7.5	28	
17.348	286.2	0.70	7.0	7.0	28	
16.35	288.9	0.71	7.3	7.3	2*n*	(4)

AB and *C*

1900 +	θ °	ρ ″	Mags.		Aper. in.	Rem.
15.353	14.0	7.44	7.0	8.5	28	
16.315	9.0	7.80	7.0	10.0	28	
17.348	12.0	7.35	6.5	9.0	28	
16.34	11.7	7.53	6.8	9.2	3*n*	(5)

5109 OΣ 216 10h 18m 30s +15° 46′

1900 +	θ °	ρ ″	Mags.		Aper. in.	Rem.
15.318	89.0	0.84	7.0	11.0	28	
17.403	78.2	0.70	7.0	11.0	28	
17.408	64.6	0.70	7.0	10.5	28	
16.71	77.3	0.75	7.0	10.8	3*n*	(6)

5461 Σ 1442 10h 27m 36s +22° 27′

1900 +	θ °	ρ ″	Mags.		Aper. in.	Rem.
15.353	156.4	13.71	7.5	8.0	28	
17.394	154.4	14.07	8.0	8.0	28	
16.37	155.4	13.89	7.8	8.0	2*n*	(7)

5657 Ho 48 10h 59m 40s +23° 35′

1900 +	θ °	ρ ″	Mags.		Aper. in.	Rem.
16.320	9.8	1.27	8.5	11.0	28	
17.403	4.0	1.39	8.1	11.0	28	
16.86	6.9	1.33	8.3	11.0	2*n*	(8)

5805 OΣ 234 11h 26m 30s +41° 44′

1900 +	θ °	ρ ″	Mags.		Aper. in.	Rem.
15.422	166.5	0.32	7.8	8.3	28	
15.441	161.3	0.38	7.0	8.0	28	
17.394	170.2	0.38	7.5	7.5	28	
17.403	165.6	0.34	7.5	7.5	28	
15.43	163.9	0.35	7.4	8.2	2*n*	(9)
17.40	167.9	0.36	7.5	7.5	2*n*	

5812 Σ 1547 11h 27m 39s +14° 49′

1900 +	θ °	ρ ″	Mags.		Aper. in.	Rem.
15.301	325.9	15.80	6.0	8.5	28	
17.394	325.4	15.82	7.5	9.0	28	
16.35	325.7	15.81	6.8	8.8	2*n*	(10)

5840 Σ 1554 $11^{h}\,31^{m}\,59^{s}$ +13° 18′

1900 +	θ	ρ	Mags.		Aper.	Rem.
	°	″			in	
15.290	258.8	0.80	8.5	8.9	28	
17.403	251.6	0.60	8.7	8.7	28	
16.34	255.2	0.70	8.6	8.8	2*n*	(11)

5866 Σ 1564 $11^{h}\,35^{m}\,27^{s}$ +27° 24′

15.301	83.6	5.19	8.8	9.2	28	
17.394	86.6	4.72	8.8	9.2	28	
16.35	85.1	4.96	8.8	9.2	2*n*	(12)

5996 Σ 1589 $11^{h}\,56^{m}\,30^{s}$ +44° 4′

15.323	157.6	2.09	9.2	9.2	28	
17.394	157.8	2.29	9.0	9.0	28	
16.36	157.7	2.19	9.1	9.1	2*n*	(13)

6018 Σ 1596 $12^{h}\,0^{m}\,11^{s}$ +21° 55′

12.163	236.2	3.58	6.2	7.5	14	
16.315	240.0	3.74	7.5	7.8	28	
16.372	237.6	3.88	7.0	8.0	28	
14.95	237.9	3.73	6.9	7.8	3*n*	(14)

6076 Σ 1613 $12^{h}\,8^{m}\,31^{s}$ +36° 13′

08.483	9.5	1.31		.	6	
08.557	8.9	1.34	.	.	6	
17.394	13.2	1.52	8.8	8.8	28	
17.403	10.0	1.33	8.4	8.6	28	
12.96	10.4	1.38	8.6	8.7	4*n*	(15)

6158 Σ 1639 $12^{h}\,20^{m}\,25^{s}$ +26° 2′

15.356	339.4	0.60	7.0	9.0	28	
15.416	343.7	0.42	8.0	9.5	28	
17.329	341.6	0.51	7.4	8.4	28	
17.403	339.8	0.57	6.8	8.0	28	
15.39	341.6	0.51	7.5	9.3	2*n*	(16)
17.37	340.7	0.54	7.1	8.2	2*n*	

6187 Σ 1647 $12^{h}\,26^{m}\,30^{s}$ +10° 10′

08.483	224.3	1.27		. .	6	
08.502	223.4	1.48			6	
08.535	224.9	1.28		. .	6	
17.329	224.0	1.33	8.0	8.3	28	
10.71	224.1	1.34	8.0	8.3	4*n*	(17)

6213 Σ 1670 $12^{h}\,37^{m}\,40^{s}$ −1° 0′

1900 +	θ	ρ	Mags.		Aper.	Rem.
	°	″			in.	
09.411	327.8	6.00	3.0	3.0	14	
09.414	326.7	6.04	.	.	14	
09.428	327.1	6.01	. .	. .	14	
17.329	322.0	6.18	3.5	3.5	28	
17.403	325.2	6.15	3.3	3.0	28	
17.408	324.1	6.09	3.0	3.2	28	
17.422	322.2	6.43	3.6	3.4	28	
09.42	327.2	6.02	3.0	3.0	3*n*	(18)
11.33	326.1	6.06	3.1	3.0	2*n*	
17.41	323.9	6.22	3.3	3.2	4*n*	

6296 Σ 1687 $12^{h}\,49^{m}\,21^{s}$ +21° 41′

A and *B*

15.356	91.2	0.90	6.0	8.5	28	
16.372	96.2	0.78	5.5	8.5	28	
17.329	94.0	0.60	5.8	8.8	28	
16.35	93.8	0.76	5.9	8.6	3*n*	(19)

A and *C*

15.356	124.6	28.45	6.0	9.5	28	
16.372	124.4	29.02	5.5	9.2	28	
17.329	125.5	28.64	5.8	9.5	28	
16.35	124.8	28.70	5.7	9.4	3*n*	

6367 β 929 $12^{h}\,59^{m}\,47^{s}$ −3° 14′

15.356	216.6	0.64	6.5	6.5	28	
17.403	214.6	0.68	6.8	6.8	28	
16.38	215.6	0.66	6.7	6.7	2*n*	(20)

6406 Σ 1728 $13^{h}\,6^{m}\,8^{s}$ +17° 58′

08.483	29.5	0.51	. .	. .	6	
08.486	12.5	0.57	.	. .	6	
08.502	20.4	0.54	.		6	
08.511	5.2	0.56		.	6	(21)
09.372	9.4	0.47	6.0	6.3	14	
09.378	12.3	0.43	5.8	5.8	14	
09.381	11.1	0.45	5.7	6.0	14	
15.307	190.2	0.56	6.0	6.0	28	
15.356	187.0	0.50	6.0	6.0	28	
15.394	194.4	0.42	5.5	5.5	28	
17.329	190.4	0.51	6.3	6.3	28	
17.394	196.0	0.40	5.5	5.5	28	
17.403	190.8	0.36	5.5	5.5	28	
08.50	16.9	0.55	. .		4*n*	(22)
09.38	10.9	0.45	5.8	6.0	3*n*	
15.35	190.5	0.50	5.8	5.8	3*n*	
16.37	193.2	0.60	6.0	6.0	1*n*	
17.38	192.4	0.42	5.8	5.8	3*n*	

6155 Σ 1734 $13^{\mathrm{h}}\,16^{\mathrm{m}}\,38^{\mathrm{s}}$ +3° 21′

1900 +	θ	ρ	Mags.		Aper.	Rem.
	°	″			in.	
08.483	191.0	1.24	. .	. .	6	
08.557	188.1	1.29	.	. .	6	
17.329	190.2	0.94	8.0	8.0	28	
11.46	190.0	1.19	8.0	8.0	3*n*	(23)

6194 OΣ 266 $13^{\mathrm{h}}\,24^{\mathrm{m}}\,32^{\mathrm{s}}$ +16° 7′

15.283	344.5	1.69	8.3	8.6	28	
17.408	346.0	1.99	8.4	8.8	28	
16.34	345.3	1.84	8.4	8.7	2*n*	(24)

6566 Σ 1768 $13^{\mathrm{h}}\,33^{\mathrm{m}}\,53^{\mathrm{s}}$ +36° 42′

09.408	127.8	0.89	6.5	8.0	14	
09.461	127.3	1.10	5.0	8.0	14	
09.480	121.0	1.22	5.0	7.8	14	
17.394	121.4	1.28	6.0	8.0	28	
17.408	126.4	1.17	6.0	7.6	28	
09.45	125.4	1.07	5.5	8.0	3*n*	(25)
17.40	123.9	1.23	6.0	7.8	2*n*	

6578 β 612 $13^{\mathrm{h}}\,35^{\mathrm{m}}\,38^{\mathrm{s}}$ +11° 9′

15.307	213.2	0.36	6.5	6.5	28	(26)
15.323	195.4	0.28	6.0	6.0	28	(27)
15.356	204.8	0.34	6.5	6.5	28	(27)
15.386	204.4	0.30	6.5	6.5	28	(27)
15.392	203.6	0.22	.	. .	28	(27)
15.394	196.4	0.24	6.0	6.0	28	(27)
16.372	210.4	0.30	6.0	6.0	28	(26)
17.394	215.0	0.25	6.0	6.0	28	(26)
17.441	217.6	0.32	7.0	7.0	28	(27)
15.36	203.0	0.29	6.3	6.3	6*n*	(28)
17.07	214.3	0.29	6.3	6.3	3*n*	

6625 β 801 $13^{\mathrm{h}}\,42^{\mathrm{m}}\,39^{\mathrm{s}}$ +11° 14′

15.392	324.4	2.68	8.5	11.8	28	
17.441	326.0	2.41	8.7	12.0	28	
16.42	325.2	2.55	8.6	11.9	2*n*	(29)

6641 Σ 1785 $13^{\mathrm{h}}\,45^{\mathrm{m}}\,29^{\mathrm{s}}$ +27° 23′

08.483	315.1	1.32	. .	. .	6	
08.532	316.0	1.35	. .	. .	6	
08.535	315.6	1.31	. .	. .	6	
17.441	353.0	1.52	7.8	8.0	28	
17.443	354.0	1.24	8.0	8.4	28	
08.52	315.6	1.33	. .	. .	3*n*	(30)
17.44	353.5	1.38	7.9	8.2	2*n*	

6780 Σ 1819 $14^{\mathrm{h}}\,11^{\mathrm{m}}\,18^{\mathrm{s}}$ +3° 30′

1900 +	θ	ρ	Mags.		Aper.	Rem.
	°	″			in.	
09.411	349.9	1.11	7.2	7.5	14	
09.428	347.0	1.11	7.7	7.7	14	
09.430	348.0	1.18	7.0	7.0	14	
17.441	345.6	1.09	7.6	7.6	28	
17.443	341.2	1.15	8.0	8.2	28	
09.42	348.3	1.13	7.3	7.4	3*n*	(31)
17.44	343.4	1.12	7.8	7.9	2*n*	

6842 β 1111 $14^{\mathrm{h}}\,19^{\mathrm{m}}\,27^{\mathrm{s}}$ +8° 49′

B and *C*

1915 and 1917	Single				28	

A and *BC* = Σ 1835

15.307	192.0	6.69	5.0	7.0	28	
15.323	188.4	6.35	.	. .	28	
15.394	189.7	6.53	5.0	7.5	28	
17.441	190.0	6.19	4.0	7.0	28	
17.443	190.8	6.66	4.5	7.5	28	
16.18	190.2	6.48	4.6	7.3	5*n*	(32)

6948 Σ 1863 $14^{\mathrm{h}}\,35^{\mathrm{m}}\,22^{\mathrm{s}}$ +51° 55′

08.502	82.6	0.62	.	. .	6	
08.535	83.5	0.62		. .	6	
08.543	82.8	0.68	.	. .	6	(33)
17.545	88.4	0.58	7.5	7.5	28	
17.561	86.8	0.51	8.0	8.0	28	
12.14	84.8	0.60	7.8	7.8	5*n*	(34)

6955 Σ 1865 $14^{\mathrm{h}}\,37^{\mathrm{m}}\,19^{\mathrm{s}}$ +14° 5′

08.483	145.0	0.35	. .	. .	6	
08.486	149.5	0.32	. .	. .	6	
08.502	144.4	0.34	. .	. .	6	
08.511	140.4	0.43	.	. .	6	
08.535	148.0	0.40		. .	6	(35)
09.356	147.0	0.42	3.0	3.2	14	
09.361	145.0	0.44	. .	. .	14	
09.375	143.7	0.49	3.5	3.7	14	(36)
10.465	138.8	0.45	4.0	4.0	14	(37)
10.474	138.1	0.55	4.0	4.6	14	
12.357	140.4	0.67	4.0	4.0	14	
15.290	139.0	0.80	4.0	4.0	28	
16.329	139.0	0.72	4.0	4.0	28	
16.372	140.2	0.78	4.0	4.0	28	
17.394	139.8	0.70	4.5	4.3	28	
17.441	140.8	0.79	3.0	3.0	28	
08.50	145.5	0.37	. .	. .	5*n*	(38)
09.36	145.2	0.45	3.3	3.5	3*n*	
11.10	139.1	0.55	4.0	4.2	3*n*	
15.99	139.4	0.77	4.0	4.0	3*n*	
17.42	140.3	0.75	3.8	3.8	2*n*	

6961 Σ 1866 14^h 37^m 51^s +9° 52′

1900 +	θ	ρ	Mags.		Aper.	Rem.
	°	″			in	
08.505	22.5	0.98		..	6	
08.557	21.5	0.99	.	..	6	
08.565	23.9	0.91		..	6	
17.441	21.6	1.05	8.7	8.7	28	
17.443	26.8	0.70	8.2	8.5	28	
12.11	23.3	0.93	8.5	8.6	5*n*	(39)

6971 Σ 1870 14^h 38^m 59^s +8° 25′

15.430	229.3	4.57	8.0	10.0	28	
17.441	229.6	3.96	8.4	11.0	28	
16.44	229.5	4.27	8.2	10.5	2*n*	(40)

6999 Σ 1879 14^h 42^m 20^s +9° 59′

09.409	131.5	0.60	7.7	8.2	14	
09.434	130.8	0.65	7.5	8.0	14	
09.436	131.8	0.80	8.0	8.2	14	
17.441	120.0	0.82	8.2	8.6	28	
17.443	113.0	0.70	8.2	8.6	28	
09.43	131.4	0.68	7.7	8.2	3*n*	(41)
17.44	116.5	0.76	8.2	8.6	2*n*	

7001 OΣ 285 14^h 42^m 29^s +42° 42′

09.436	114.4	0.38	7.5	7.8	14	
09.445	120.4	0.36	7.5	7.5	14	
09.450	105.8	0.38	8.0	8.0	14	(42)
17.545	93.4	0.41	8.2	8.2	28	(43)
17.561	94.6	0.38	7.8	7.8	28	(44)
09.44	113.5	0.38	7.7	7.8	3*n*	(45)
17.55	94.0	0.40	8.0	8.0	2*n*	

7031 Σ 1888 14^h 47^m 41^s +19° 27′

09.414	149.3	2.30	4.0	7.0	14	
09.436	152.2	2.25	4.0	6.5	14	
09.439	149.7	2.43	4.0	6.8	14	
17.441	86.0	1.69	5.0	7.5	28	
17.443	86.2	1.91	5.0	8.0	28	
09.43	150.4	2.33	4.0	6.8	3*n*	(46)
17.44	86.1	1.80	5.0	7.8	2*n*	

7049 OΣ 288 14^h 49^m 38^s +16° 3′

09.376	185.0	2.00	6.0	7.0	14	
09.453	187.5	1.80	7.0	7.2	14	
09.463	186.5	1.78	6.5	7.0	14	
17.441	189.0	1.60	6.0	8.0	28	
17.443	188.6	2.00	6.0	7.0	28	
09.43	186.3	1.86	6.5	7.1	3*n*	(47)
17.44	188.8	1.80	6.0	7.5	2*n*	

7120 Σ 1909 15^h 1^m 12^s +47° 57′

1900 +	θ	ρ	Mags.		Aper.	Rem.
	°	″			in.	
09.411	243.4	4.01	.	..	14	
09.439	243.5	4.25	5.0	6.3	14	
09.450	239.4	4.10	..	..	14	
17.545	243.6	3.90	5.8	7.0	28	
17.561	245.6	3.96	6.0	7.0	28	
09.44	242.1	4.12	5.0	6.3	3*n*	(48)
17.55	244.6	3.93	5.9	7.0	2*n*	

7214 Σ 1932 15^h 14^m 54^s +27° 7′

08.543	340.2	0.37	.		6	
08.557	324.2	0.39			6	
08.565	325.6	0.41			6	(49)
09.378	344.2	0.56	6.5	6.5	14	
09.405	346.0	0.52	.	..	14	
09.411	349.7	0.60	..	..	14	
17.441	8.2	0.64	7.0	7.0	28	
17.443	8.4	0.63	7.0	7.0	28	
08.56	330.0	0.39	.	.	3*n*	(50)
09.40	346.6	0.56	6.5	6.5	3*n*	
17.44	8.3	0.64	7.0	7.0	2*n*	

7251 Σ 1937 15^h 19^m 54^s +30° 34′

08.434	31.5	1.05		..	6	
08.456	31.3	1.07		.	6	
08.483	31.6	1.06		.	6	
08.500	31.3	1.11		.	6	
08.502	32.0	1.10			6	
08.511	32.4	1.09			6	
09.381	35.0	1.00	5.2	5.5	14	
09.403	33.9	0.98	5.0	5.5	14	
09.405	32.3	0.97	.	..	14	
17.331	71.0	0.66	6.3	6.3	28	
17.394	69.2	0.64	6.5	6.8	28	
17.441	70.0	0.91	5.5	5.7	28	
08.48	31.7	1.08	..		6*n*	(51)
09.40	33.7	0.98	5.1	5.5	3*n*	
12.08	40.9	0.70	5.5	6.5	1*n*	
17.39	70.1	0.74	6.1	6.3	3*n*	

7259 Σ 1938 15^h 21^m 32^s 37° 37′

08.505	57.2	1.14	..	..	6	
08.532	57.6	1.13	..	..	6	
08.535	59.8	1.17		..	6	
09.414	60.1	0.96	6.0	7.0	14	
09.428	56.9	1.00	..	..	14	
09.430	60.8	0.98	..	..	14	
17.441	47.6	1.23	7.0	7.2	28	
17.545	49.4	1.35	7.5	8.0	28	
17.561	52.6	1.12	7.5	8.3	28	
08.97	58.7	1.06	6.0	7.0	6*n*	(52)
17.52	49.9	1.23	7.3	7.8	3*n*	

7318 Σ 1954 $15^h 31^m 0^s$ +10° 48′

1900+	θ °	ρ ″	Mags.		Aper. in.	Rem.
08.511	185.7	3.99	.	..	6	
08.532	186.1	3.95	.		6	
08.542	186.0	4.02	.	..	6	
10.546	183.8	3.60	4.0	5.0	14	
17.441	187.0	3.98	3.0	5.0	28	
17.457	186.2	4.61	4.5	6.0	28	
08.53	185.9	3.99	..	.	3*n*	(53)
15.15	185.7	4.06	3.8	5.3	3*n*	

7332 OΣ 298 $15^h 33^m 13^s$ +40° 4′

08.505	191.4	1.35	.	..	6	
08.546	192.5	1.37		..	6	
08.597	191.7	1.42		..	6	
09.404	190.4	1.12	.	..	14	
09.439	191.0	1.13	7.0	7.2	14	
09.450	192.5	1.12	7.0	7.1	14	
17.545	202.6	0.75	7.0	7.0	28	
17.561	205.2	1.12	7.5	7.5	28	
17.739	199.4	0.96	7.8	7.8	28	
08.55	191.9	1.38	..	..	3*n*	(54)
09.43	191.3	1.12	7.0	7.2	3*n*	
17.62	202.4	0.94	7.5	7.5	3*n*	

7345 Hu 652 $15^h 35^m 2^s$ +49° 5′

08.543	178.6	0.67	..	..	6	
08.557	180.5	0.65	..	.	6	
08.560	178.9	0.68	..	.	6	(55)
17.545	176.2	0.64	8.9	9.0	28	
17.561	175.6	0.51	8.5	8.8	28	
12.15	178.0	0.63	8.7	8.9	5*n*	(56)

7360 Hu 580 $15^h 38^m 0^s$ +19° 55′

15.411	72.0	0.25	5.0	5.0	28	(57)
17.441	uncertain		..	..	28	
17.443	77.4	0.20	6.0	6.0	28	(58)
17.446	72.2	0.20	5.0	5.0	28	(58)
16.77	73.9	0.22	5.3	5.3	3*n*	(59)

7368 Σ 1967 $15^h 39^m 24^s$ +26° 33′

08.505	115.4	0.71	..	6.5	6	
08.560	116.9	0.75	..	6.5	6	
08.565	116.9	0.78	..	6.5	6	(60)
09.430	120.0	0.86	..	..	14	
09.434	127.8	0.77	4.2	7.0	14	
09.436	114.4	0.78	4.0	6.5	14	
10.474	109.6	0.75	4.0	6.5	14	
10.497	107.8	0.71	4.0	6.0	14	
10.498	113.5	0.70	4.0	6.0	14	
17.441	116.6	0.58	5.0	7.0	28	
17.443	116.4	0.45	5.0	7.0	28	
08.54	116.4	0.75	..	6.5	3*n*	(61)

7368 Σ 1967 — (*Continued.*)

1900+	θ °	ρ ″	Mags.		Aper. in.	Rem.
09.96	115.5	0.76	4.0	6.4	6*n*	
17.41	116.5	0.52	5.0	7.0	2*n*	

7477 OΣ 303 $15^h 57^m 10^s$ +13° 30′

08.508	143.1	0.72		..	6	
08.511	143.0	0.76	.	..	6	
08.532	145.9	0.78	.	..	6	(62)
17.443	154.2	0.84	8.2	8.2	28	
17.446	151.0	1.09	7.8	7.8	28	
08.52	144.0	0.76		..	3*n*	(63)
17.44	152.6	0.97	8.0	8.0	2*n*	

7563 Σ 2032 $16^h 11^m 42^s$ +34° 4′

09.414	216.2	4.76	5.0	6.0	14	
09.439	217.4	5.16	5.0	5.5	14	
09.453	217.0	4.80	5.0	5.5	14	
17.739	220.2	4.82	6.0	7.4	28	
17.742	218.4	5.39	5.0	6.0	28	
09.44	216.9	4.91	5.0	5.8	3*n*	(64)
17.74	219.3	5.11	5.5	6.7	2*n*	

7587 OΣ 309 $16^h 16^m 35^s$ +41° 51′

15.307	71.2	0.24	8.5	8.5	28	
17.739	82.0	0.30	8.4	8.4	28	
17.742	67.4	0.42	8.8	8.8	28	
16.93	73.5	0.32	8.6	8.6	3*n*	(65)

7637 Σ 2049 $16^h 24^m 37^s$ +26° 9′

08.565	205.5	1.21	.	..	6	
08.570	203.0	1.25		..	6	
09.464	200.0	1.20	7.0	8.0	14	
09.480	210.2	1.17	7.0	8.2	14	
09.499	203.6	1.01	7.0	8.0	14	
17.443	203.0	0.99	7.5	8.0	28	
17.446	204.2	1.23	7.5	8.5	28	
08.57	204.3	1.23	.	..	2*n*	(66)
09.48	204.6	1.13	7.0	8.1	3*n*	
17.44	203.6	1.11	7.5	8.3	2*n*	

7642 Σ 2052 $16^h 25^m 24^s$ +18° 35′

08.557	87.9	1.41	.	..	6	
08.565	89.8	1.44	..	..	6	
08.570	88.4	1.44	..	..	6	
09.411	88.3	1.06	7.5	7.5	14	
09.414	79.2	1.08	..	..	14	
09.423	91.0	1.11	..	..	14	
17.443	45.4	0.20	8.0	8.0	28	
17.446	48.6	0.34	7.8	7.8	28	
08.56	88.7	1.43	.		3*n*	(67)
09.41	86.2	1.08	7.5	7.5	3*n*	
17.44	47.0	0.27	7.9	7.9	2*n*	

7649 Σ 2055 16h 26m 53s +2° 10′

1900+	θ °	ρ ″	Mags.		Aper. in.	Rem.
09.411	64.6	1.06	4.2	6.3	14	
09.414	64.3	0.92		.	14	
09.425	66.0	0.91	4.5	5.6	14	
10.521	68.6	1.00	4.5	5.5	14	
10.529	66.8	1.05	..	..	14	
16.591	74.0	0.82	5.0	6.0	28	
17.413	75.2	1.12	5.0	6.5	28	
17.446	78.8	0.82	5.0	6.5	28	
08.57	60.9	1.31	..	..	1*n*	(68)
09.86	66.1	0.99	4.4	5.8	5*n*	
17.16	76.0	0.92	5.0	6.3	3*n*	

7673 OΣ 313 16h 29m 50s +40° 17′

08.565	141.8	0.98		.	6	
08.570	144.5	0.98	.	..	6	
17.739	146.0	0.70	7.0	8.0	28	
17.742	145.4	0.69	7.5	8.0	28	
13.15	144.4	0.84	7.3	8.0	4*n*	(69)

7717 Σ 2084 16h 38m 20s +31° 44′

09.414	158.8	1.14	3.0	6.0	14	
09.430	150.0	1.04	3.0	6.5	14	
09.436	153.5	1.02	3.0	7.0	14	
17.452	101.6	1.42	2.0	8.0	28	
17.742	99.4	1.29	3.5	7.0	28	
09.43	154.1	1.07	3.0	6.5	3*n*	(70)
17.60	100.5	1.36	2.8	7.5	2*n*	

7739 Σ 2094 16h 40m 49s +23° 40′

10.546	78.0	1.33	7.0	7.5	14	
17.742	77.4	1.93	8.0	8.0	28	
14.14	77.7	1.63	7.5	7.8	2*n*	(71)

7748 De 15 16h 41m 28s +43° 38′

09.408	284.4	0.30	8.0	8.0	14	
09.430	287.2	0.38		.	14	
09.434	296.8	0.36			14	(72)
17.742	251.8	0.36	8.5	8.5	28	
17.758	252.4	0.45	8.0	8.0	28	
09.42	289.5	0.35	8.0	8.0	3*n*	(73)
17.75	252.1	0.41	8.3	8.3	2*n*	

7779 β 627 16h 46m 51s +46° 8′

09.436	322.7	1.08	5.2	10.0	14	
09.461	323.0	1.50	5.0	10.5	14	
09.480	326.3	1.57	4.8	9.5	14	
17.745	326.0	1.00	5.0	11.0	28	
17.758	335.0	1.09	4.5	9.8	28	
17.761	330.6	1.23	5.0	9.8	28	
09.46	324.0	1.38	5.0	10.9	3*n*	(74)
17.76	330.5	1.11	4.8	10.2	3*n*	

7783 Σ 2107 16h 48m 40s +28° 48′

1900+	θ °	ρ ″	Mags.		Aper. in.	Rem.
09.408	0.0	0.28	6.2	..	14	
09.434	11.0	0.32	7.0	9.0	14	
09.439	5.8	0.34	6.0	8.0	14	(75)
10.474	15.0	0.40	6.0	10.0	14	(76)
10.497	13.8	0.46	6.0	9.0	14	
15.356	22.8	0.64	6.5	9.0	28	
17.446	20.4	0.52	6.0	8.5	28	
17.449	18.2	0.56	6.0	8.5	28	
09.43	5.6	0.32	6.4	8.5	3*n*	(77)
10.48	14.4	0.43	6.0	9.5	2*n*	
16.75	20.5	0.57	6.2	8.7	3*n*	

7817 Σ 3107 16h 54m 51s +4° 5′

09.409	91.5	1.30	8.5	8.5	14	
09.414	93.2	1.11	8.0	8.0	14	
09.428	93.0	1.00	..	..	14	
17.446	94.2	1.63	8.2	8.2	28	
17.449	92.8	1.53	8.4	8.6	28	
12.63	92.9	1.31	8.3	8.3	5*n*	(78)

7822 Σ 2112 16h 55m 13s +31° 54′

15.307	260.5	2.09	8.9	9.5	28	
17.441	260.0	1.87	8.8	9.2	28	
16.37	260.3	1.98	8.9	9.4	2*n*	(79)

7832 OΣ 322 16h 56m 58s +37° 2′

15.353	201.4	1.47	8.0	10.0	28	
17.745	205.4	1.15	8.5	10.8	28	
16.55	203.4	1.31	8.3	10.4	2*n*	(80)

REMARKS

(1) No apparent change since the discovery in 1843.

(2) Comparison with the orbits of Lohse and Doberck gives the following residuals: (O — C)

	Lohse		Doberck	
	$\Delta\theta$ °	$\Delta\rho$ ″	$\Delta\theta$ °	$\Delta\rho$ ″
1911.18	+0.6	−0.13	−0.3	−0.16
1917.33	+1.8	+0.10	+0.8	−0.05

The first orbit has a period of 249 years and the second, 347.

(3) No appreciable change in the last twenty years.

(4) Direct motion of 30° since 1833.

(5) There may possibly be a very small increase in the position angle.

(6) The retrograde motion is now rapid. The faint companion is closing in and the measures become difficult.

(7) This wide pair appears to be relatively fixed. Dawes in 1831 measured 155°.6, 13″.62.

(8) Apparently fixed.

Hough 1882.74 6°.7 1″.66

(9) The pair was separated on the four nights. On the second night it was noted that the fainter component was certainly in the second quadrant.

Comparison with See's orbit gives: (O — C)

	Δθ	Δρ
	°	″
1915.43	−5.3	−0.09
1917.40	−5.0	−0.07

The first computed orbit of this system was by Gore in 1886, period 63 years. That by See gave 77 years. The companion has described 350° since 1843.

The period given by See in 1895 will prove very nearly correct.

(10) The change in one hundred years has been extremely small, although the common proper-motion is as much as 0″.4.

(11) There may be a very small decrease in distance.

(12) No apparent change in 90 years.

(13) The very few previous observations of this pair agree with these later measures.

(14) No apparent relative motion in 100 years.

(15) Although usually noted as unchanged in the catalogues, it seems that the pair is in slow retrograde motion.

(16) The retrograde motion has become a little slower than anticipated.

(17) Very slow direct motion of 0°.3 a year without apparent change in distance.

(18) Comparison with See's orbit gives: (O — C)

	Δθ	Δρ
	°	″
1909.42	+0.3	−0.23
1911.33	−0.2	−0.23
1917.41	−0.8	−0.18

When a difference of magnitude was noted, the fainter component was placed in the second quadrant.

(19) This binary is now closing in rapidly and will soon become a difficult object to observe.

(20) Although very slow, a retrograde motion seems certain.

(21) The components were of course not separated with the 6-inch object glass, but the spurious discs could be seen cutting into one another.

(22) Comparison with See's orbit gives: (O — C)

	Δθ	Δρ
	°	″
1908.50	+5.0	+0.05
1909.38	−1.0	−0.08
1915.35	−1.1	−0.02
1916.37	+1.3	+0.12
1917.50	+0.5	−0.01

(23) This pair can scarcely be referred to as "evidently a very slow binary." It has no known proper-motion and relative change is doubtful. The mean of Dembowski and Schiaparelli observations gives:

1870 192°.7 1″.14 7*n*

(24) It is curious that a close pair of this kind appears from the relative motion to be an optical double star.

(25) Comparison with See's orbit gives: (O — C)

	Δθ	Δρ
	°	″
1909.45	+0.1	−0.27
1917.40	+2.7	−0.23

(26) Elongated.

(27) Separated.

(28) Comparison with Aitken's orbit gives: (O — C)

	Δθ	Δρ
	°	″
1915.36	+4.2	−0.01
1917.42	+8.3	−0.04

The period will probably be nearer 22 years than 23.

(29) No apparent change.

(30) The motion has become more rapid than anticipated.

(31) The distance has probably decreased since 1900.

(32) On each of these nights the duplicity of *BC*, β 1111 could not be seen with certainty. It must have been very close at the time.

(33) On the three nights with the 6-inch the components were almost separated.

(34) Retrograde motion of 0°.3 a year without apparent change in distance.

(35) The 6-inch showed at the time this pair as an image 2^{mm} by 1.5^{mm} observed at 0.80^{m} from the eye.

(36) Well separated by the 14-inch in 1909.

(37) Widely separated from 1910 onwards.

(38) Hertzsprung's recent orbit represents these observations fairly well, as the distance measured with the 6-inch was probably too small.

(39) Another close equal pair having shown no motion in 90 years.

(40) No apparent change.

(41) The increase in distance is slower than expected.

(42) Well separated with the 14-inch on the three nights.

(43) Separated at times.

(44) Not separated.

(45) Very little change in distance in the last 20 years.

(46) The motion is more rapid than anticipated. Lohse's orbit still requires correction. The residuals (O — C) are:

	$\Delta\theta$ °	$\Delta\rho$ ″
1909.43	−0.7	0.00
1917.44	−4.7	−0.46

(47) It is not yet certain that apastron has been reached.

(48) The distance has decreased of 1″ since 1885.

(49) Measures difficult with the 6-inch, but elongation quite apparent.

(50) Motion rapid. I see no difference in the magnitudes of the components.

(51) Comparison with Lohse's orbit gives the following residuals: (O — C)

	$\Delta\theta$ °	$\Delta\rho$ ″
1908.48	−0.8	+0.01
1909.40	−1.7	−0.08
1912.08	−3.4	−0.30
1917.39	+1.6	0.00

(52) Lohse's orbit represents these observations well.

(53) There is as yet no indication that the maximum distance has been reached.

(54) Celoria's orbit gives positions agreeing fairly well with these observations.

(55) Almost separated by the 6-inch.

(56) Possibly unchanged. Hussey gave:
1904.31 172°.0 0″.77

(57) Very fine definition. The pair is separated by the 28-inch.

(58) Not separated.

(59) It is curious that a bright close pair of this class should appear to have no motion. Hussey gave: 1902.54 71°.8 0″.21

(60) On the three nights the pair was well separated by the 6-inch. I am surprised that this double star is usually referred to as a difficult object.

(61) The retrograde motion is at present not quite so rapid as that given by Lewis's orbit.

(62) Well separated by the 6-inch.

(63) There is little doubt that this is a binary.

(64) According to Lewis's orbit this is about the maximum separation.

(65) There has been a recent decrease in the distance. The star was separated on two nights.

(66) Extremely slow motion.

(67) Movement has been rapid since 1908. The pair was not quite separated by the 28-inch in 1917.

(68) It is not yet possible to say with certainty which of the two periods, 130 or 200 years, will be the true one.

(69) The decrease in angle is extremely slow.

(70) Comparison with Comstock's recent orbit gives: (O — C)

	$\Delta\theta$ °	$\Delta\rho$ ″
1909.43	+1.0	−0.13
1917.60	−0.2	−0.15

(71) No change in 80 years.

(72) Just separated.

(73) The companion has now been observed through an arc of 240°.

(74) There seems to be a decrease in distance lately.

(75) Almost separated.

(76) Widely separated from 1910 onwards.

(77) The orbits by Lewis and Lohse make the present direct motion faster than observed.

(78) There is certainly retrograde motion.

(79) Not the least change in 96 years.

(80) No change in 70 years.

Royal Observatory, Greenwich, 1918, March 19.

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MEASURES OF DOUBLE STARS, BY ROBERT JONCKHEERE.

EDITOR, BENJAMIN BOSS, ALBANY, N. Y.; ASSOCIATE EDITORS, E. E. BARNARD, ERNEST W. BROWN, F. R. MOULTON AND R. S. WOODWARD.
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ANALYSIS OF THE REAL MOTIONS OF THE STARS (PAPER I),

By BENJAMIN BOSS.

The list of parallaxes determined by ADAMS and JOY in *Ap. J.*, Vol. XLVI, No. 5, from a study of their spectra, contains 219 stars whose radial velocities have been published, and whose proper-motions are given in the *Preliminary General Catalogue*. The material is thus available for the derivation of the apices of their real motions, and their space velocities.

The formulæ employed in computing the coördinates of the stellar apices and the space velocities are taken from *A. J.*, No. 707.

$$\tan\phi = \frac{\pi v_\odot \sin d \sin\chi = C\mu \sin\theta}{\pi v_\odot \sin d \cos\chi = C\mu\cos\theta}$$

$$\tan\Delta = \frac{v_\odot \sin d \sin(\theta - \chi)}{\sin(\theta - \phi)\,(\rho + v_\odot \cos d)}$$

$$\sin D = +\cos\delta \sin\Delta \cos\phi + \sin\delta\cos\Delta$$

$$\cot(A - \alpha) = -\sin\delta\cot\phi + \cos\delta\cot\Delta\,\mathrm{cosec}\,\phi$$

$$v = \frac{(\rho + v\cos d)}{\cos\Delta}$$

Where ϕ = Position angle of stellar apex
π = Star's parallax
$v_\odot$ = *Sun's* velocity
d = Angular distance of the solar apex
χ = Position angle of the solar apex
C = 4.74
μ = Star's proper-motion
θ = Position angle of observed proper-motion
Δ = Angular distance of stellar apex
ρ = Star's observed radial velocity
A, D = Right ascension and declination of star's apex
α, δ = Right ascension and declination of star's position
v = Space velocity of star.

The assumed apex of solar motion is R. A. = 270°.5, Decl. = +34°.3 and the assumed solar velocity is 20 km.

The computed positions of the apices and the space velocities are exhibited in Table I. Giant and dwarf stars are distinguished in the last column by the designations *g* and *d*. Where the designation is missing there is some doubt to which class the star belongs.

Figure I shows the distribution of the stellar apices. The coördinates are right ascension and declination, and the curve represents the position of the Galaxy. The striking feature of the diagram is the condensation of apices approximately 180° apart in right ascension, which is merely a manifestation of preferential motion. The crosses mark the vertices of preferential motion as determined from large and from ordinary proper-motions. The two crosses furthest from the equator mark the vertices of preferential motion derived from large proper-motion stars; the two crosses nearest the equator mark the vertices derived from miscellaneous proper-motions.

Two phenomena are immediately apparent. Whereas the vertex of large proper-motion stars fits the group of apices in right ascension 90°, the mean proper-motion vertex is more satisfactory for the group of apices in right ascension 270°. Or looking at the matter in another way, the apices near Vertex I lie almost without exception above the equator, while the apices near Vertex II are equally distributed on both sides of the equator.

This phenomenon became the subject of further discussion. The list was divided into two groups, one containing stars whose proper-motion exceeds 0″.2, the other containing stars whose proper-motion is less than 0″.1. The apices of the large proper-motion stars are represented in Figure 2. The preferential motion is represented by two groups of stars fairly compact and diametrically opposite one another. There is some indication that the vertex of preferential motion as determined from large proper-motions alone is not exactly representative of the true position though it is not badly displaced. The apices are

TABLE I.

P.G.C.	*A*	*D*	*r*		*P.G.C.*	*A*	*D*	*r*	
	°	°	km			°	°	km	
90	290.7	+29.9	15.4	*g*	1373	92.2	−18.5	97.5	*g*
127	90.0	+ 2.7	84.0	*d*	1420	284.3	+ 7.0	31.3	*d*
130	239.5	−42.6	109.5	*g*	1456	131.3	−65.8	133.5	*g*
132	18.5	+29.3	8.8	*g*	1472	149.1	+ 7.9	19.5	*g*
135	299.4	+39.5	6.2	*g*	1476	288.1	+61.0	28.1	*g*
168	52.2	+35.1	22.0	*d*	1606	251.5	+50.1	19.4	*g*
259	316.3	+57.2	6.9	*g*	1627	94.5	−14.1	120.5	*g*
321	84.0	+30.7	24.2	*d*	1673	91.8	+26.1	34.0	*d*
325	265.3	−24.5	14.4	*g*	1717	246.3	+58.4	10.9	*g*
335	341.3	+44.4	18.0	*g*	1725	60.9	−27.1	23.8	*g*
349	280.6	+10.7	18.9	*g*	1783	89.3	− 7.9	80.8	*g*
350	262.1	−37.9	36.1	*d*	1815	263.4	+51.4	15.9	*g*
382	247.7	−34.4	48.8	*d*	1868	76.1	+70.4	19.9	*g*
391	269.4	+32.1	50.5	*d*	1931	18.3	− 1.6	16.7	*g*
420	267.1	+13.7	16.4	*g*	2008	304.9	−12.0	18.0	*d*
498	257.9	− 0.7	20.2	*g*	2020	295.2	+20.1	33.3	*g*
617	57.4	+69.7	29.3	*d*	2021	359.2	+21.5	11.6	*g*
639	260.5	+35.6	13.0	*g*	2023	137.8	− 9.5	53.6	*g*
654	274.7	+27.7	8.0	*d*	2031	5.5	+18.5	32.0	*g*
691	244.8	− 1.7	38.2	*g*	2034	2.3	+ 4.5	62.6	*d*
698	89.9	− 0.2	48.3	*g*	2148	141.6	+13.3	42.1	*g*
710	109.9	+39.8	73.2	*d*	2150	275.5	+ 8.6	22.6	*g*
718	110.2	+32.5	32.9	*g*	2168	254.0	−12.0	21.9	*d*
772	264.8	+28.3	16.1	*g*	2195	127.2	+34.1	11.5	*g*
814	329.3	+18.0	27.9	*d*	2236	265.2	−78.3	43.9	*d*
825	356.0	−32.8	34.7	*d*	2272	324.9	+43.8	17.0	*d*
847	261.2	+ 5.7	25.7	*g*	2336	149.9	−55.2	35.9	*g*
848	294.2	+73.1	65.6	–	2338	272.5	−12.6	22.6	*g*
915	56.2	−18.7	46.5	*g*	2354	122.5	+25.3	27.3	–
933	357.1	+16.6	15.9	*g*	2410	113.4	−37.6	26.8	*g*
936	145.9	+ 6.5	13.0	*g*	2413	110.4	+52.5	27.3	*d*
984	284.7	−35.5	110.7	*d*	2464	82.1	+44.4	64.7	*d*
1000	110.7	+21.4	37.9	*g*	2469	62.4	+10.0	44.2	*d*
1014	245.7	+13.2	22.1	*g*	2470	64.1	+16.2	30.9	*d*
1017	96.5	+29.7	32.4	*g*	2549	308.5	−22.5	30.4	–
1044	106.4	+21.0	36.6	*g*	2552	84.2	+15.3	34.5	*d*
1045	97.7	+30.7	31.0	*g*	2573	68.1	+ 2.1	44.1	*d*
1077	63.6	+22.8	44.1	*g*	2602	120.3	+28.9	22.2	*g*
1128	209.3	−67.5	33.9	*g*	2734	121.4	+26.8	41.3	*d*
1140	111.9	+50.6	19.2	*d*	2750	75.8	−79.8	8.8	*d*
1167	19.1	+76.8	17.1	*g*	2775	192.7	−40.4	43.4	*d*
1185	274.1	+31.0	13.4	*g*	2806	282.4	+ 1.8	62.0	*d*
1187	263.0	+ 6.0	19.9	*g*	2822	283.4	−43.7	64.8	*d*
1211	259.6	+11.1	18.2	*g*	2897	83.5	+18.3	71.6	–
1246	77.6	+45.8	27.1	*g*	2899	202.7	−19.1	49.1	*g*
1259	100.1	+27.2	66.1	*d*	2910	59.8	−26.6	51.5	*g*
1309	263.4	−11.6	21.6	*g*	2921	286.0	−15.3	27.6	–
1323	263.9	+10.6	33.7	*g*	2935	331.9	−61.3	93.4	*d*
1334	272.8	+23.6	26.9	*g*	2942	135.8	− 2.6	120.3	*g*
1347	68.4	+27.5	8.7	*g*	2943	68.6	− 5.7	57.2	*d*

TABLE I — *Continued.*

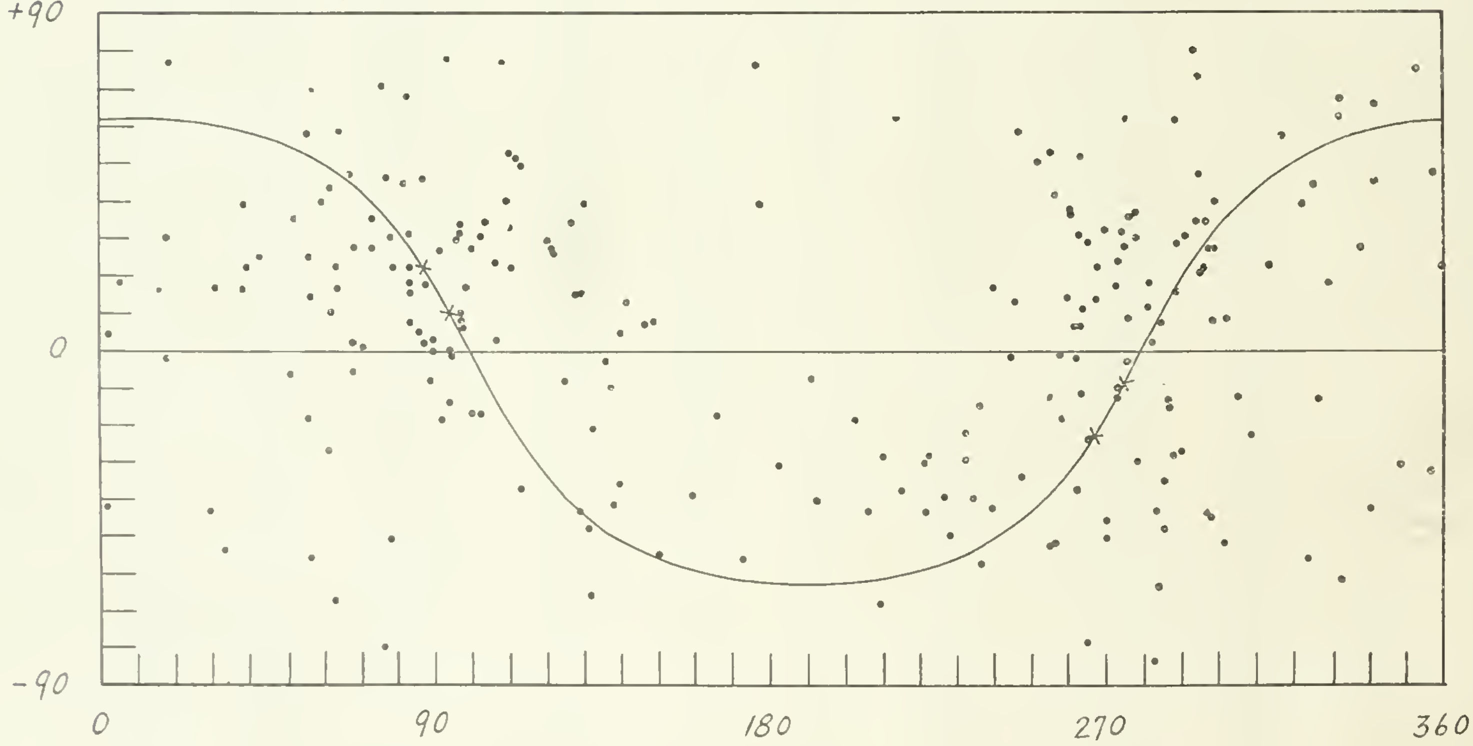
P.G.C.	*A*	*D*	*v*		*P.G.C.*	*A*	*D*	*v*	
	°	°	km			°	°	km	
2958	277.3	+29.6	12.8	*g*	4108	64.9	+59.0	59.3	*g*
2980	79.3	+22.4	17.1	*g*	4134	16.2	+16.2	6.9	*g*
2983	326.1	−13.0	66.4	–	4137	296.0	−44.0	46.0	*d*
2984	323.5	−55.8	15.0	*d*	4138	166.0	−17.3	19.7	*d*
2989	93.9	+77.3	59.1	*g*	4192	313.8	+22.4	6.0	*g*
3014	73.7	+27.3	62.0	*d*	4193	281.2	+17.6	9.7	*g*
3015	78.3	+29.7	51.9	*d*	4204	125.2	− 8.7	13.8	*g*
3069	70.8	+ 0.8	77.3	*d*	4246	94.5	− 0.1	66.1	*d*
3089	190.7	− 7.8	54.6	*g*	4303	321.9	+39.1	116.8	–
3098	293.4	+79.6	9.8	–	4371	129.1	−43.8	18.1	*d*
3105	261.8	− 1.9	51.8	*d*	4373	73.9	+35.1	21.4	*g*
3137	285.2	−48.6	42.2	*d*	4403	62.0	−67.0	72.4	*d*
3145	138.1	−41.2	119.6	–	4438	38.5	+16.3	12.9	*g*
3279	59.6	+39.8	195.0	*d*	4497	228.6	−50.0	43.2	–
3294	31.1	+16.5	14.2	*g*	4541	283.1	−83.5	11.1	*g*
3307	55.9	+25.0	28.2	*d*	4571	300.9	−51.6	19.2	*d*
3326	232.7	−29.7	102.2	–	4582	256.0	+41.2	21.2	*d*
3367	87.9	+ 1.2	53.4	*g*	4629	298.8	+26.5	21.9	*g*
3383	84.2	+22.4	30.4	*g*	4638	205.8	−43.5	83.5	*g*
3424	83.0	+68.0	49.3	*d*	4656	33.6	−54.0	68.6	*g*
3534	61.5	+43.5	41.6	*g*	4665	104.3	+34.4	33.8	*g*
3558	99.2	+16.6	31.5	*d*	4672	294.5	+46.3	54.2	*d*
3635	240.1	+16.4	25.3	–	4705	269.7	−50.6	68.9	*g*
3642	274.5	+61.8	37.5	*g*	4753	275.3	− 3.6	46.0	*d*
3650	51.0	− 5.9	29.3	*d*	4814	87.8	+17.7	16.2	*g*
3662	172.4	−55.9	66.4	*g*	4815	78.6	−50.7	26.3	*d*
3704	209.8	−28.9	25.2	*d*	4892	128.2	+14.5	56.0	*d*
3717	55.7	+58.4	25.4	*g*	4893	129.6	+14.7	52.3	*d*
3729	296.3	+34.1	34.5	*d*	4909	331.7	+67.2	43.8	*g*
3734	97.1	+33.7	118.7	*d*	4912	159.3	−39.4	14.4	*g*
3758	278.2	−29.8	29.0	*d*	4923	86.1	+ 4.9	21.8	*g*
3771	341.1	+65.6	8.1	*g*	4961	255.8	−51.7	102.1	*d*
3798	268.0	+22.2	25.2	*d*	4976	139.6	−35.8	75.2	*g*
3809	255.2	+57.5	33.2	*g*	5009	302.1	+ 8.8	85.3	*d*
3813	298.6	−45.3	63.4	*d*	5014	139.9	+ 4.5	18.1	*d*
3836	283.8	−63.3	9.0	*g*	5037	226.2	−39.7	25.0	*d*
3887	289.7	−27.1	39.6	*g*	5044	221.9	−28.8	82.5	*g*
3895	258.3	−18.5	82.5	*d*	5047	277.5	+36.1	17.3	*g*
3907	232.5	−22.3	25.2	–	5052	275.6	+35.2	22.8	*g*
3926	177.0	+75.7	12.4	*d*	5071	214.0	+61.8	9.9	*g*
3940	102.8	+30.0	21.5	*g*	5093	131.0	−48.4	32.9	–
3952	287.7	−28.4	104.5	*g*	5144	29.6	−44.0	83.0	*d*
3959	348.1	−30.7	35.2	*g*	5146	246.1	−18.0	44.9	*d*
4001	297.7	+26.8	39.4	*g*	5163	100.3	−17.1	30.2	*d*
4015	56.3	−55.7	27.0	*g*	5180	56.6	+14.3	87.1	*d*
4040	235.8	−14.7	62.1	*d*	5218	272.7	+16.8	20.3	*d*
4055	269.6	−46.0	64.0	*d*	5219	39.4	+39.4	17.5	*d*
4090	113.9	+49.3	19.2	*d*	5229	263.0	+30.3	15.4	*g*
4096	337.6	+27.3	44.3	*g*	5291	106.7	+ 2.9	10.7	*g*

TABLE I — *Continued.*

P.G.C.	*A*	*D*	*v*		*P.G.C.*	*A*	*D*	*v*	
	°	°	km			°	°	km	
5321	177.4	+38.3	16.6	*d*	5865	289.8	+28.2	20.7	*g*
5335	254.8	−52.5	41.5	*g*	5868	220.9	−30.6	23.2	*g*
5336	76.7	+46.9	47.3	*g*	5875	40.8	+22.2	10.7	*g*
5346	132.4	−20.7	93.9	*g*	5891	286.5	−13.6	32.7	*g*
5433	97.4	+ 8.2	91.9	*d*	5894	43.4	+25.3	41.5	*d*
5434	97.9	+ 5.6	87.6	*d*	5920	102.3	−16.9	40.4	*d*
5452	298.5	+ 7.8	36.9	*g*	5940	352.5	+74.7	26.1	*g*
5455	236.4	−57.4	16.2	*d*	5972	234.4	−40.0	51.3	*d*
5543	288.5	+15.3	29.8	*g*	5976	94.8	− 1.0	48.8	*d*
5559	87.6	+45.4	17.9	*d*	5981	97.3	+10.0	72.6	*g*
5584	294.3	+34.2	20.6	*g*	5988	83.5	+ 7.3	104.9	*g*
5592	260.2	+37.5	15.0	*d*	6024	130.4	+38.4	15.4	–
5651	272.9	−10.2	51.0	*d*	6077	1.4	−42.0	13.4	*d*
5676	295.6	+26.5	21.5	*g*	6078	221.6	−44.0	39.2	*g*
5688	331.3	+67.4	11.1	*d*	6106	108.5	+76.5	41.4	*g*
5790	339.9	−43.4	93.5	*g*	6135	215.0	−38.1	37.8	*g*

Fig. 1

Stellar Apices Based on Parallaxes of Adam's List. Ap. J. Vol. XLVI



fairly evenly distributed among the two groups. It would require a great number of stars selected according to limiting magnitude to determine the probable relative distribution. The average of the space velocities of 40 stars belonging to Vertex I is 55 km., while the average space velocity of 28 stars belonging to Vertex II is 58 km. As far as these large proper-motion stars are concerned the indications are that the assumed

Fig. 2 Apices of Large P.M. Stars. P.M > ".20

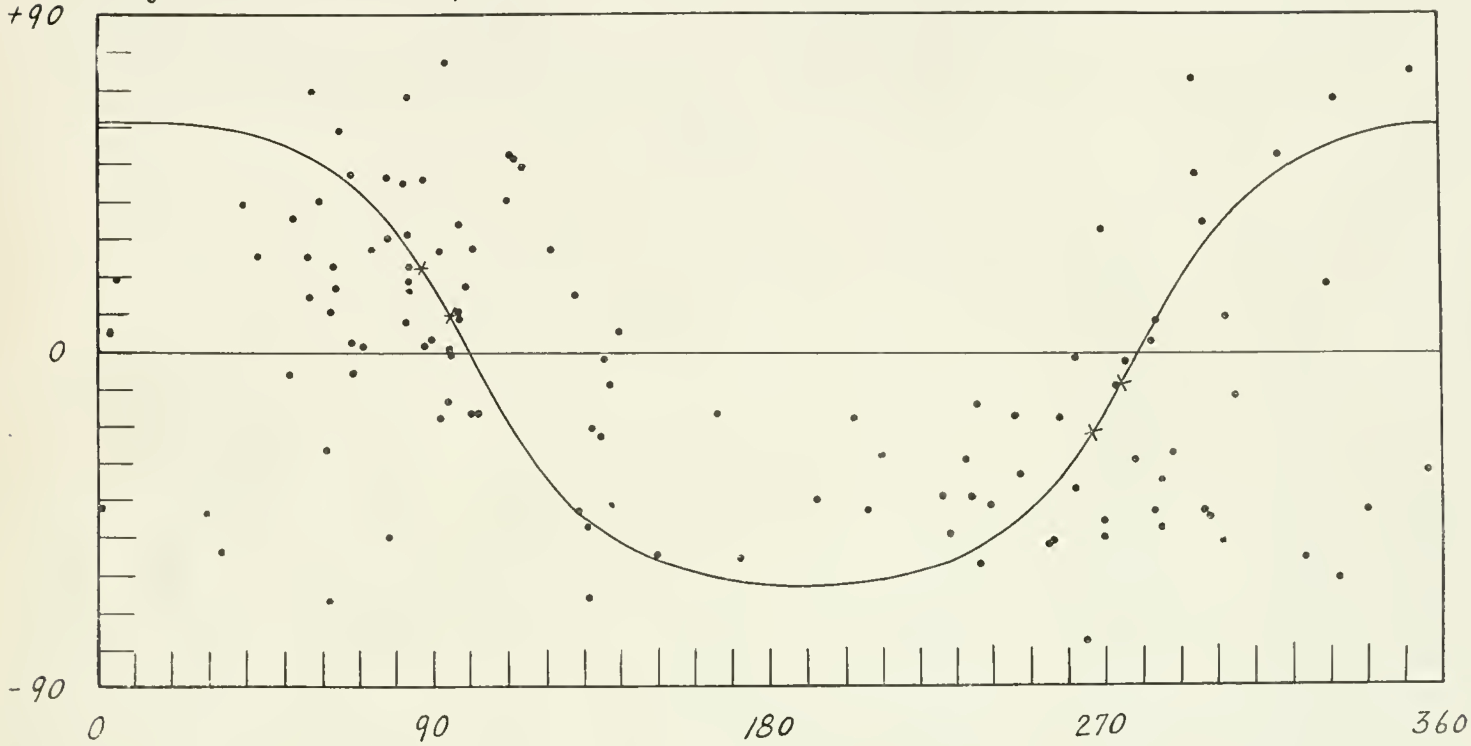
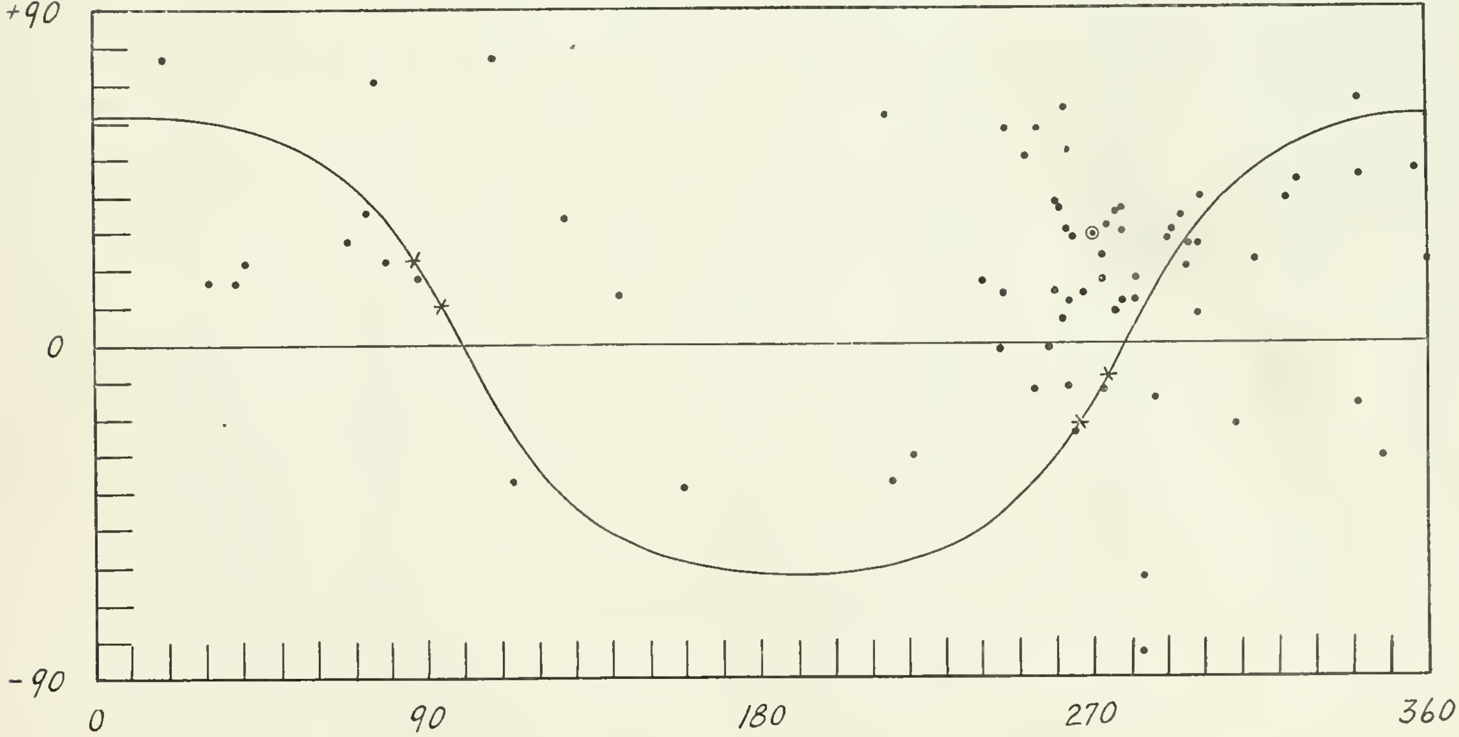


Fig. 3 Apices of Small P.M. Stars. P.M. < ".10



solar motion is substantially correct. Another point of interest is that 32 of the 40 stars belonging to Vertex I are dwarf stars, and 22 of the 28 stars belonging to Vertex II are also dwarf stars. In all, the large proper-motion groups, whose real velocities are directed toward the vertices of preferential motion, contain 54 dwarf stars and 12 giant stars. The large average velocity of 56 km. confirms the hypothesis suggested by Prof. Lewis Boss in *A. J.* No. 614 to the effect that, "among the larger proper-motions, there is

TABLE II.

P. G. C	*A*	*D*	*v*		*d*	Meas.	Est.
			km		°		
90	290.7	+29.9	15.4	*g*	97.1	*K* 2	*K* 5
135	299.4	+39.5	6.2	*g*	66.3	*G* 8	*G* 8
325	265.3	−24.5	14.1	*g*	56.9	*F* 8	*F* 8
349	280.6	+10.7	18.9	*g*	63.6	*G* 5	*G* 6
420	267.1	+13.7	16.4	*g*	81.7	*K* 1	*K* 2
498	257.9	− 0.7	20.2	*g*	70.3	*F* 7	*F* 5
639	260.5	+35.6	13.0	*g*	80.7	*G* 4	*K* 3
691	244.8	− 1.7	38.2	*g*	122.1	*G* 8	*M a*
772	264.8	+28.3	16.1	*g*	88.5	*F* 7	*F* 5
847	261.2	+ 5.7	25.7	*g*	96.6	*F* 6	*F* 5
1014	245.7	+13.2	22.1	*g*	119.5	*G* 5	*M a*
1185	274.1	+31.0	13.4	*g*	84.1	*F* 8	*F* 7*p*
1187	263.0	+ 6.0	19.9	*g*	100.6	*F* 7	*F* 5*p*
1211	259.6	+14.1	18.2	*g*	162.0	*K* 1	*K* 4
1309	263.1	−11.6	24.6	*g*	82.4	*G* 8	*M a*
1323	263.9	+10.6	33.7	*g*	164.0	*G* 1	*G* 1
1334	272.8	+23.6	26.9	*g*	70.6	*G* 8	*M a*
1606	251.5	+50.1	19.4	*g*	96.3	*G* 5*p*	*K* 3
1717	246.3	+58.4	10.9	*g*	119.9	*G* 2	*G* 8
1815	263.4	+51.4	15.9	*g*	123.5	*G* 0	*F* 8*p*
2020	295.2	+20.1	33.3	*g*	126.4	*G* 5	*M b*
2150	275.5	+ 8.6	22.6	*g*	74.6	*G* 4	*G* 5
2168	254.0	−12.0	21.9	*d*	120.1	*F* 9	*F* 8
2338	272.5	−12.6	22.6	*g*	105.0	*G* 3	*G* 3
2549	308.5	−22.5	30.4	–	69.3	*G* 2	*G* 3
2921	286.0	−15.3	27.6	–	82.0	*G* 9	*M a*
2958	277.3	+29.6	12.8	*g*	75.5	*G* 9	*G* 9
3635	240.1	+16.4	25.3	–	51.4	*F* 8	*F* 7
3809	255.2	+57.5	33.2	*g*	46.4	*K* 1	*K* 4
4192	313.8	+22.4	6.0	*g*	31.7	*G* 5	*G* 6
4193	281.2	+17.6	9.7	*g*	64.9	*G* 2	*M a*
4629	298.8	+26.5	21.9	*g*	10.3	*K* 0	*K* 2
5047	277.5	+36.1	17.3	*g*	32.8	*G* 9	*K* 3
5052	275.6	+35.2	22.8	*g*	27.5	*G* 1	*M a*
5218	272.7	+16.8	20.3	*d*	31.0	*F* 4	*F* 3
5229	263.0	+30.3	15.4	*g*	27.5	*G* 0	*F* 9*p*
5452	298.5	+ 7.8	36.9	*g*	39.2	*G* 7	*G* 6
5584	294.3	+34.2	20.6	*g*	55.2	*G* 4	*K* 0
5592	260.2	+37.5	15.0	*d*	47.6	*F* 3	*F* 2
5676	295.6	+26.5	21.5	*g*	65.7	*F* 8	*G* 0*p*
5865	289.8	+28.2	20.7	*g*	57.4	*G* 3	*G* 2
	272.7	+18.9	20.7				

proportionally a greater number of stars that have abnormally large rectilinear motions, peculiar to the stars themselves."

Figure 3 shows the apices of stars whose proper-motion is less than 0″.1. A very striking feature is the grouping of apices in the vicinity of the solar apex which is marked by the solar symbol. Practically all of the apices which might be expected to mark Vertex II lie north of the equator. Table II lists the computed position of the apices, the space velocity, and the distance of the star from the solar apex. The mean velocity of 20.7 km. for the group directed toward the vicinity of the solar apex might at first sight seem to indicate a group of which the *Sun* is a member. Further inspection shows these stars to be giants while the *Sun* is a dwarf star. However, for the sake of distinction I will hereafter refer to the group as the Solar Group. The lowest space velocity is 6.0 km. and the highest 38.2 km. In view of the fact that some apices would normally be expected in this region it is rather surprising that the range of space velocities is not larger, corresponding with conditions in other regions of the sky. Of the 41 stars 23 have space velocities between 15 km. and 25 km.

It is natural to consider whether the effect may not be due to systematic errors. As for the parallaxes, a systematic increase of 0″.1 would, in the mean, shift the apices only about 10° in the direction of the assumed solar apex. Taking a very unfavorable case, *P. G. C.* 2921, whose apex is located so far south as to make its membership in the group doubtful, the assumed parallax of 0″.030 places the apex at *A* = 286°.0, *D* = −15°.3 with a space velocity of 27.6 km.; while the trigonometrical parallax of 0″.079 shifts the position of the apex to *A* = 307°.0, *D* = − 15°.8 with a space velocity of 25.4 km.

If on the other hand the assumed solar motion is considered in error *P. G. C.* 5584 offers an unfavorable case. If Campbell's values of *A* = 268°.5, *D* = +25°.2 and velocity of 19.5 km. are used the apex of this star is placed at *A* = 284°.1, *D* = +25°.8 with a space velocity of 20.6 km.; while Table II places the apex at *A* = 294°.3, *D* = +34°.2 with a space velocity of 20.6 km.

Likewise the assumption of a reasonable systematic error in either proper-motion or radial velocity has relatively little effect upon the position of the group apex. Certainly it would require far greater systematic errors than could be admitted to displace the group vertex by some 30° to fit Vertex II.

For individual stars there may be considerable change in the position of the apex and in the space velocity due to systematic errors. If the star is located nearly 90° from its apex a very slight error in the observed radial velocity will greatly affect the value of the space velocity.

If the 41 stars of Table II are solved for solar motion using the radial velocities the resulting motion relative to the *Sun* is toward an apex at *A* = 286°.8, *D* = −43°.7 and the velocity is 8.9 km. By adopting the solar apex *A* = 270°.5, *D* = +34°.3 and a solar velocity of 20 km., the resultant motion for the group is toward an apex at *A* = 270°.8, *D* = +12°.6 at the rate of 23.3 km.; or if Campbell's determination of solar motion is used where *A* = 268°.5, *D* = +25°.2 and the solar velocity is 19.5 km., the resultant apex of the Solar Group is at *A* = 268°.1, *D* = +5°.1, with a group velocity of 23.9 km.

It is interesting to see how far the results may be affected by peculiar distribution of the stars used. Table III shows the comparison of observed with theoretically even distribution with regard to the apex of solar motion. The agreement is good considering the few stars employed, certainly good enough to show that peculiar distribution of the stars is not responsible for the results obtained.

TABLE III.

Distance from Apex or Antapex	No. Stars Obs.	No. Stars Comp.	O — C
0 — 10 170 — 180	0	1	−1
10 — 20 160 — 170	3	2	+1
20 — 30 150 — 160	2	3	−1
30 — 40 140 — 150	4	4	0
40 — 50 130 — 140	2	5	−3
50 — 60 120 — 130	8	6	+2
60 — 70 110 — 120	7	6	+1
70 — 80 100 — 110	6	7	−1
80 — 100	9	7	+2

Fig. 4 Apices of Giant Stars.

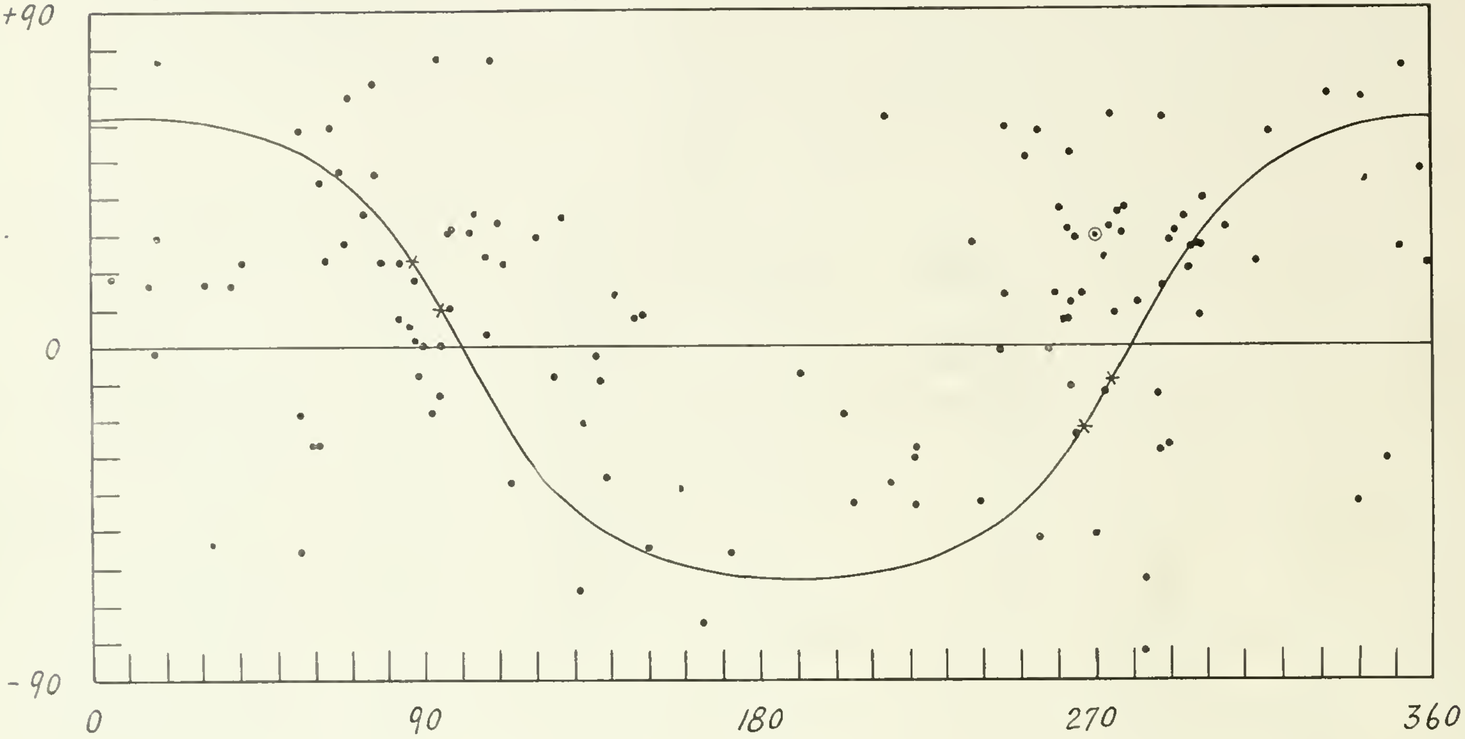
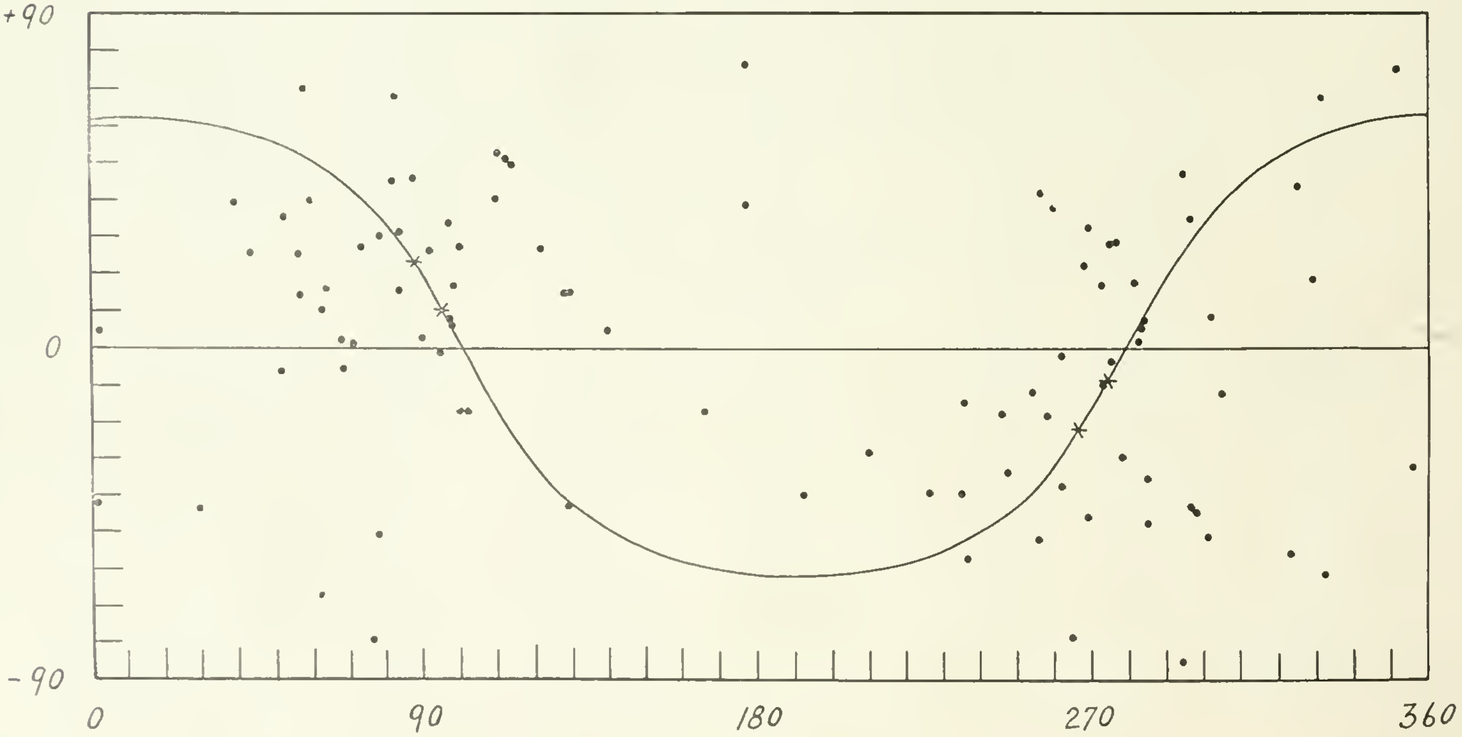


Fig. 5 Apices of Dwarf Stars.



No account was taken of the K term in the solutions for individual star apices or in the solution for group motion. But over half the stars are of F and G type, where the K term is zero, so its inclusion for the K and M types would not appreciably alter the general results. As the stars listed in Table I are mainly confined to the northern hemisphere a slight shift in the position of the solar apex and in the amount of solar motion might be expected by the inclusion of the K term.

The bulk of the stars belonging to the Solar Group are giants. This leads to a consideration of the distribution of apices according to giant and dwarf divisions, to determine whether the Solar Group must be attributed to giant stars, to small proper-motion stars, or to both. Figure 4 differs very decidedly from Figure 3, for in addition to the strong grouping of apices north of the equator at R. A. 270° there is a good representation of Vertex I and many other apices are strung along the Galaxy. A surprising feature is the solution for solar motion of the 124 giant stars by means of their radial velocities. The *Sun's* apex is placed at $A = 269°.3$, $D = +23°.4$, and its velocity at 25.6 km. The position of the apex corresponds almost exactly with CAMPBELL's general solution $A = 268°.5$, $D = +25°.2$, whereas a very different position might have been expected *a priore* from the peculiar distribution of the apices of the real motions. The Solar Group is a prominent feature of the giant stars, whereas the usual grouping about Vertex II is lacking. It is probably safe to say that the Solar Group is mainly composed of giant stars.

The apices of the dwarf stars are represented in Figure 5. The strong representation of the Solar Group is lost, though a trace remains, and the grouping about Vertex II becomes the chief feature. Solving for solar motion using radial velocities alone places the solar apex at $A = 275°.2$, $D = +24°.8$ and the solar velocity at 16.0 km. This position, as determined by dwarf stars, agrees very well with the one derived from giant stars, but there is a difference of 9.6 kilometers between the two values of the solar velocity. This seemed to indicate a relative drift between the two classes, giants and dwarfs, along the direction of solar motion.

Since it is inadvisable to rely upon the results obtained from one element of the problem only the next is to treat it from the standpoint of the space velocities of the stars where the only uncertainty results from the inaccuracy of the data. The results obtained in Table I were computed with an assumed solar velocity of 20 km. and an assumed apex $A = 270°.5$, $D = +34°.3$. If these space velocities be reduced to the rectangular coördinates x, y, z, which in this case we will take as the usual equatorial coördinates, the mean x, mean y, and mean z determine the error in the assumed values of solar motion for the particular stars under consideration. For the giants the errors are $x = -2.0$, $y = +3.4$, $z = -1.0$. For the dwarfs $x = +3.8$, $y = +4.7$, $z = -0.2$. For all combined $x = +0.4$, $y = +3.9$, $z = -0.6$. Applying these errors to the assumed values for solar motion the corrected results become

	A °	D	v	No. Stars
Giants	276.3	+31.5	23.4	124
Dwarfs	260.2	+28.1	24.7	91
All	269.1	+30.2	23.8	215

The results are in remarkable agreement considering the small amount of material. Such close agreement indicates that giants and dwarfs belong to the same general system. The relative drift deduced from the use of radial velocities is apparently not real. Therefore the unweighted combination of the giant and dwarf stars in one solution designated by "all" is justified and produces a much more reliable value of solar motion. It is of special interest to note the relation of these results to those derived from a consideration of radial velocity, or of proper-motion. If the apex of solar motion as derived from proper-motions by L. BOSS (*A. J.* 614) be taken as representative of proper-motion solutions, and CAMPBELL's value derived from radial velocities (*L. O. B.* 196) be compared with it, the mean of the two results is in almost perfect agreement with that derived above.

	A	D	v
Proper-motion	270.5	+34.3	24.5
Radial velocity	268.5	+25.2	19.5
Mean	269.5	+29.8	22.0
Space velocities	269.1	+30.2	23.8

It is probably safe to say that the solar apex lies very close to $A = 270°$, $D = +30°$. It is also probable that the true solar velocity is 22 or 23 kilometers. There is apparently a distinct difference between results obtained from proper-motions and radial velocities. A possible explanation lies in the effect produced by the large peculiar velocities of the stars in high galactic latitudes.

However, when dealing with proper-motions only, or radial velocities only it is not proper to assume the true value of solar motion, as it would produce a false center of the velocity figure. For each element those values of solar motion must be assumed which fit it.

The apices of the dwarf stars are so symmetrically placed that the vertex of preferential motion can almost be derived from a mere inspection of Figure 5. With the giants the case is quite otherwise. Following the general method suggested by RAYMOND in *A. J.*, No. 718, it is a simple matter to determine the principal axes of the velocity figure. Consider the coordinates x, y, z, of each apex referred to equatorial coördinates. Then

$$\begin{aligned} v \cos \alpha \cos \delta &= x \\ v \sin \alpha \cos \delta &= y \\ v \sin \delta &= z \end{aligned}$$

Where α, δ are the right ascension and declination of the star's apex and v is its space velocity.

If the direction cosines of a preferential axis be designated by l, m, n, the following equations afford the means of placing it.

$$\begin{aligned} (\overline{xx} - \lambda)\, l + \overline{xy}\, m + \overline{xz}\, n &= 0 \\ \overline{xy}\, l + (\overline{yy} - \lambda)\, m + \overline{yz}\, n &= 0 \\ \overline{xz}\, l + \overline{yz}\, m + (\overline{zz} - \lambda)\, n &= 0 \end{aligned}$$

and

$$\begin{vmatrix} \overline{xx} - \lambda & \overline{xy} & \overline{xz} \\ \overline{xy} & \overline{yy} - \lambda & \overline{yz} \\ \overline{xz} & \overline{yz} & \overline{zz} - \lambda \end{vmatrix} = 0$$

The three axes determined from these equations define the axis of preference, the axis of avoidance, and the intermediate axis. The three values of λ are the mean square components of the velocity figure.

Though the differential corrections to solar motion for dwarf and giant stars differed but little it was deemed advisable to use the true center for each velocity figure. The results are contained in Table IV.

The pole of preference for both dwarf and giant stars is located on the galactic equator, but there is a separation of about 29° between the two. This adds one more phenomenon pointing to the Galaxy as at least the principal plane of reference. The low declination of the pole of preference for the giant stars is due to the influence of the Solar Group. The pole of avoidance of the giant stars is very accurately placed at the galactic pole, while the corresponding pole of the dwarf stars is approximately 20° from the giant pole. This offers an explanation of the differences obtained between solutions of large proper-motion stars and of the general run of proper-motions. In the first case the majority of stars are dwarf stars; in the second case there is a preponderance of giant stars. Table V illustrates the point. The pole of preference of the dwarf stars is almost coincident with that of the large proper-motion stars. If twice the weight of the dwarf stars be given to the giant stars the resulting pole of preference fits the general results very satisfactorily. In other words there are apparently at least twice as many giant stars as dwarfs in the *Preliminary General Catalogue.*

Comparison of the pole of preference derived by RAYMOND from a discussion of the small proper-motion stars (*A. J.*, No. 718) with that of the giants indicates that they are for the most part giants. The comparison is shown in Table V.

Table V also shows a comparison of the pole of preference derived by COMSTOCK from the proper-motions of faint stars (*A. J.*, No. 655) with the pole of preference for the dwarf stars. COMSTOCK derives the formula $m\mu = C$. The mean magnitude of the COMSTOCK stars is 9.7 that of the *P. G. C.* 5.7. This indicates roughly a difference of forty times the light between the two, and taking into account the relative distances of the two as indicated by the formula, COMSTOCK's stars are 1/14 times as luminous as those of

TABLE IV.

	Pole of Preference		Intermediate Pole		Pole of Avoidance		Mean Square Motions			Mean Motions		
	A_1	D_1	A_2	D_2	A_3	D_3	λ_1	λ_2	λ_3	V_1	V_2	V_3
	°	°	°	°	°	°				km	km	km
Dwarfs	85.5	+29.9	275.6	+59.8	188.0	+ 4.3	2053.2	492.3	361.8	45.3	22.2	19.0
Giants	98.2	+ 3.7	0.2	+65.0	189.9	+24.7	1007.9	660.5	299.7	30.7	25.7	17.3

TABLE V.

Large P. M.			General P. M.			Small P. M.			Faint Stars		
	°	°		°	°		°	°		°	°
DYSON	88	+21	EDDINGTON	94	+12	RAYMOND	91.9	+4.2	COMSTOCK	87	+28
BELJAWSKY	86	+24	L. BOSS	98	+ 9	Giants	98.2	+3.7	Dwarfs	85.5	+29.9
Dwarfs	85.5	+29.9	Mean of 8	96	+ 9						
			2/3 Giants + 1/3 Dwarfs	94.0	+12.4						

TABLE VI.

Type	Pole of Preference *A*	*D*
	°	°
A	92.4	+ 1.8
F	93.1	+ 2.1
G	93.8	+ 3.4
Giants	98.2	+ 3.7
K	93.1	+11.3
M	94.0	+25.3
Dwarfs	85.5	+29.9

the *P.G.C.* This means that the great majority of the Comstock stars are dwarfs. The agreement of the pole of preference of these stars with the dwarf pole is exact.

It is evident that the question of dwarf or giant must, in the future, play an all-important role in the discussion of systematic motion. It is more important than the discussion by type. In fact the discrepancies between the positions of the pole of preference derived from stars of different type can readily be explained by Table VI, which is in part an excerpt from Raymond's article in *A. J.*, No. 718. These results are chosen as an illustration because Mr. Raymond has perhaps accounted more thoroughly for possible sources of disturbance than other investigators of the problem. The division between giant and dwarf stars in the *A* and *F* types is not great. It is natural to suppose that any radical difference dependent upon the choice of giant or dwarf stars would approximate giant conditions for these classes of stars. With succeeding types *G*, *K*, and *M* the dwarf influence would be more decidedly felt. Table VI shows a distinct progression from giant to mixed giant and dwarf with progression in type. Types *A* and *K* have over double the weight of the other types.

Eddington and Hartlay (*M. N.* LXXV, p. 521) have treated the systematic motions by type from radial velocities. Gyllenberg also (*Med. fran Lunds Ast. Obs.*, Serie II, *Nr.* 13) has treated the question from the standpoint of radial velocities. In Table VII the results of the two radial velocity solutions are combined with Raymond's results to form a mean for the divisions *A F G*, and *K M*. As in Table VI the *A F G* type mean approximates the giant conditions while the *K M* type mean is a mixture of dwarfs and giants.

TABLE VII.

Type	*A*	*D*
	°	°
A F G	87.5	+ 5.0
Giants	98.2	+ 3.7
K M	91.5	+15.7
Dwarfs	85.5	+29.9

All the evidence, therefore, points to giant and dwarf influence as the determining factor in any solution for systematic motion regardless of any other selective factor, as far as the direction of the axes of the velocity figure is concerned. The relative length of the axes of the velocity figure presents another problem.

Table VIII lists some of the determinations of the ratio of the axes. In each case the axis most nearly directed toward the galactic pole is taken as the unit. The velocity figure of the dwarf stars is seen to be comparatively long and slim. The intermediate direction of the velocity figure of the giants is far more pronounced. There is a physical explanation of this. While the average space velocity of the Solar Group is only 21 km. and the space velocity of the giant stars directed toward galactic longitude 324° is about 35 km. those stars whose apices are located near the galactic equator from longitude 0° to 180°, a region intermediate between the two groups mentioned, have exceedingly large space velocities. Stromberg (*Ap. J.*, Vol. XLVII, No. 1) has published three diagrams showing the projection upon the galactic equatorial plane of the velocity figures of very bright, bright, and faint stars. In his Figures 4 and 5, which evidently represent a large proportion of giant stars, the solar group is strongly shown directed toward 190° longitude. In fact in Figure 4 he has chosen to flatten the curve at that point, evidently considering the outlying dot as abnormal. The group directed toward longitude 324°

TABLE VIII.

RATIO OF AXES.

	Raymond			Stromberg*			Gyllenberg*	Boss		Raymond		Eddington* and Hartley	
	Small P. M.	Large P. M.	All	Very Bright	Bright	Faint		Giants	Dwarfs	*A*	*K*	*A*	*K*
Preferential	1.71	1.95	1.84	1.31	1.25	1.26	1.12	1.77	2.38	3.16	1.60	2.33	1.77
Intermediate	1.23	1.16	1.36	0.85	0.84	0.68	0.81	1.49	1.17	1.89	1.28	1.42	1.43
Gal. Pole	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00

* Radial Velocities.

is a second striking feature, while the third is the bowing out between longitudes 0° and 180°. Figure 1 of this article also shows a comparative scarcity of apices along the galactic equator in the vicinity of longitude 280° (R. A. = 10°) corresponding to the indentations at longitude 256° in Stromberg's figures. It is possible that fourth order terms would shift Stromberg's indentation toward 280°. It is surprising to find any giant stars moving at the rate of 134, 120, 110, and 104 kilometers and when that motion is confined to a restricted direction the case becomes still more interesting and will bear further investigation. A superficial glance at the plotted apices of Figure 4 would lead to the supposition that the center of the velocity figure had not been obtained. It is the large space velocities moving toward points in the southern hemisphere which balance the velocity figure.

In his general solution Raymond obtains values for the ratio of axes closely following the mean between giant and dwarf results. The large proper-motions, which include a majority of dwarf stars, have a more elongated velocity figure. Stromberg and Gyllenberg, who worked with radial velocities, obtained quite different results. Both found the axis directed toward the galactic pole to be intermediary between the other two, whereas proper-motion results, and the results of this investigation show it to be a minimum.

The discordance between proper-motion and radial velocity determinations of the relative length of the axes of the velocity figure is probably attributable to the large peculiar motions of stars in high galactic latitudes. For proper-motions their effect would be to over-emphasize the length of the axes in the equatorial galactic plane; for radial velocities they would over-emphasize the length of the axis directed toward the galactic pole. Therefore the results for length of axes obtained from either radial velocities alone or proper-motions alone are untrustworthy. It is probable that the mean of the two results would more nearly approximate the true axes. Where, as in the present case, space velocities are dealt with the actual velocity figure is obtained.

Table VIII also shows the results for the axes obtained by Raymond and Eddington for types *A* and *K*. These two types were selected as examples of the effect of type progression upon the axes because of their weight. Whether the mean between Raymond's and Eddington's results be taken, or whether they be considered separately, the elongation of the velocity figure for the *A* type stars is very much more decided than that for the *K* type. It seems probable therefore that types play an important part in determining the shape of the velocity figure, but they have little if any influence in its orientation.

Reverting to the Solar Group, and using the x, y, z coördinates to determine the group velocity the group apex is located at $A = 271^\circ.8$, $D = +16^\circ.3$ with a group velocity of 18.5 km., if L. Boss' position of solar motion is used with a solar velocity of 20 km. Correcting for dx, dy, dz as computed from the combined giant and dwarf results, the apex of the Solar Group is placed at $A = 270^\circ.3$, $D = +15^\circ.7$, with a group velocity of 22.4 km. This corresponds so closely with solar motion that we must seriously consider the *Sun's* membership in this group.

SUMMARY

As far as it is possible to rely upon results deduced from a small number of stars the following phenomena connected with systematic stellar motion are indicated.

1. There is a definite Solar Group moving in the direction $A = 270^\circ.3$, $D = +15^\circ.7$ at the rate of 22 km. per second. This group is for the most part composed of giant stars.

2. The solar motion determined from dwarf stars is in sufficient agreement with that determined from giant stars to support the conclusion that they belong to the same system.

3. Combining giant and dwarf material the value of solar motion becomes $A = 269^\circ$, $D = +30^\circ$ with a velocity of 23.8 km., a result in excellent agreement with the mean between radial velocity and proper-motion results.

4. There is a distinct difference between the velocity figures of dwarf and giant stars both as to orientation and the relative length of the axes. The velocity figure of the dwarf stars is fairly symmetrical, that of the giant stars is a clover leaf figure produced by the Solar Group, one wing of the dwarf figure, and a group of high velocity stars whose motions are directed along the galactic equator from longitudes 0° to 180°.

5. The orientation of the velocity figure is independent of spectral type but dependent upon giant of dwarf classification. The axes of the velocity figure are dependent upon both type and giant or dwarf classification.

The inclusion of the *B* and *A* types in the discussion or systematic motion may alter these results.

CONTENTS.

ANALYSIS OF THE REAL MOTIONS OF THE STARS, BY BENJAMIN BOSS.

EDITOR, BENJAMIN BOSS, ALBANY, N. Y.; ASSOCIATE EDITORS. E. E. BARNARD, ERNEST W. BROWN, F. R. MOULTON AND R. S. WOODWARD.
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THE STELLAR SYSTEM Σ 1306 = ♅ III .54 σ² *URSÆ MAJORIS,*

By ERIC DOOLITTLE.

This interesting object is composed of the 4.8 magnitude star, σ^2 *Ursæ Majoris*, described by Σ as of a greenish color, and of a faint companion whose magnitude is variously estimated from 8.2 to 10.0, and which has been suspected of variability. When discovered by ♅ in 1783, the two components were about 10″ apart; at the present time they are separated by a distance which probably slightly exceeds 1″.

A complete list of the measures is given below. When these are plotted, it is seen that notwithstanding the early wide separation of the stars and notwithstanding the fact that no determinate parallax of the bright star has as yet been secured, a slight curvature of the path is quite strongly suggested. The pair thus seems to merit a detailed investigation. As it is but one of some forty-nine similar pairs, all of which during the past year have been investigated in practically the same way, but the results of which investigations have not yet been published, a brief description of the mode of procedure may be of interest.

In the beginning it is assumed in each case that the motion is rectilinear. Having plotted the individual observations and drawn a straight path through them, the ephemeris is computed from this rough approximation by the formulas,

$$\cot\,(\theta - \alpha) = \mu\,\frac{(t-T)}{g}\ ;\ \rho = \frac{p}{\sin\,(\theta-\alpha)}\,,$$

in which α is the angle made by the path with the hour circle of the principal star, (measured in the usual manner from the North through the East); p is the distance apart of the two stars at the time of their nearest approach; T is the time at which this position is attained, and μ is the yearly rectilinear motion.

After this has been done, suitable normal places are formed, and the differential corrections to the four elements above described are deduced by a least-square solution. Except in three cases, the adjustment was made by the employment of the position angles only. With pairs in which the separation is not great, it seems quite certain that the inclusion of the erratic measured distances (especially those obtained by the earlier observers) will diminish, rather than add to, the accuracy. It is evident that for obtaining the scale of the orbit, (that is, the value either of μ or of p in ″) recourse must be had to the distances themselves, and this was done by merely forming the arithmetic mean of the values of p, computed from the second formula above, the other elements having been previously adjusted. In the three cases referred to, the motion was so nearly toward or away from the principal star that an inclusion of the measured distances became necessary, for under such conditions a slight variation in the measured angle produces a large variation of position on the apparent path. The formulas for this need not here be written since they were practically identical with those developed by Frank Schlesinger in the investigation of the motion in 61 *Cygni*, and published in *The Publications of the Allegheny Observatory*, Vol. II, No. 2.

If the measured angles alone are included, the differential equations take the form,

$$\left[\frac{t-T}{p}\sin^2\,(\theta-\alpha)\right]\Delta\mu - \left[\frac{\mu}{p}\,(\sin^2\,(\theta-\alpha)\right]\Delta T - \Delta\alpha = -\,(\theta_o - \theta_c).$$

It is, strictly speaking, only $\frac{\mu}{p}$ which can be determined from measures of angle; when p is found from the measures of distance, the value of μ is therefore finally so changed as to give to $\frac{\mu}{p}$ its adjusted value.

The final result of the adjustment may be assumed to define the motion as accurately as it can be deduced from the observations, upon the assumption that this motion is rectilinear. If, however, there is a definite indication of orbital motion, this will be principally revealed in two different ways:

(*a*) The curvature of the path may become evident, the residuals in distance being first minus, afterward plus, and finally minus again.

(*b*) The yearly velocities along the path as determined from date to date will not be uniform, but will increase as the companion draws nearer to periastron.

In the case of Σ 1306, the following nine places were formed from the list of observations. In the fourth column there is stated the precession in angle to the epoch 1880.0; the fifth column contains the observed position angles corrected to this epoch. The roughly approximate elements were first improved by a least-square adjustment, by which the [*vv*] was reduced from 18.5167 to 2.9563. The residuals from this second set of elements are given in the sixth column.

Date	θ_0	ρ_0	Prec.	$\theta_0 + pr.$	$\theta - \theta_1$	$\theta - \theta_2$	Observers
	°	″	°	°	°	°	
1820.46	266.95	6.44	+0.62	267.57	+1.46	+0.72	Σ 2*n*
1835.90	262.64	4.51	+0.46	263.10	−0.05	−0.72	Σ 10*n* [(wt. 4)
1842.46	261.75	4.42	+0.39	262.14	+0.57	−0.07	(Da. 2*n*, Ch. 2*n*, K. 4*n*, Ma. 2*n*), (wt. 1 each); OΣ 3*n*,
1854.72	258.03	3.72	+0.26	258.29	+0.91	+0.38	OΣ 2*n*, (wt. 2); Δ 12*n*, (wt. 4)
1864.50	253.10	3.24	+0.16	253.26	+0.61	+0.23	Δ 16*n*
1873.23	246.44	2.84	+0.07	246.51	−0.10	−0.29	OΣ 2*n*, (wt. 2); Δ 4*n*, (wt. 4); Δ 3*n*, (wt. 3)
1882.17	236.85	2.37	−0.02	236.83	−0.67	−0.56	OΣ 2*n*, (wt. 1); Hl. 5*n*, (wt. 1); [HΣ 1*n*, wt. 1; Ha. 3*n* wt. 3], (wt. 4)
1898.65	207.31	4.33	−0.19	207.12	+0.06	+0.84	Lv. 2*n*, (wt. 2) Br. 1*n*, (wt. 1); Doo. 4*n*, (wt. 4); Br. 6*n*, (wt. 6)
1905.98	186.65	4.22	−0.27	186.38	−1.44	−0.50	β 2*n*, (wt. 3); Bi. 2*n*, (wt. 1)

As the values of the differential corrections were so large, (that of α being no less than 3°.3), and as the run of the residuals was not wholly satisfactory, it was thought desirable to repeat the process for a third approximation. If in order to render the equations homogeneous, we write,

$$x = 10\,\Delta\mu \times 57.2958; \quad y = \frac{1}{100}\Delta T \times 57.2958; \quad z = \Delta\alpha,$$

the normal equations become, —

$$\begin{aligned}
+2.468753x + 5.734485y + 4.245000z &= +4.123320\\
+5.734485x + 49.822978y + 15.538000z &= -6.748260\\
+4.245000x + 15.538000y + 9.000000z &= +1.230000
\end{aligned}$$

From the solution of these we obtain the third and final set of elements given below, and the residuals of column seven, above: the value of [*vv*] is only reduced to 2.5924 as a result of this final solution.

Elements

	I (Graphical)	II	III	
T	1905.13	1905.132	1904.434	± $0^{\text{y}}.185$
α	96°.8	100°.12	101°.04	± 0°.49
μ	0″.0697	0″.06554	0″.06789	± 0″.0013*
p	1″.247	1″.384	1″.442	± 0″.032
[*vv*]	18.5167	2.9563	2.5924	

*From the angle solution alone. From the distances we obtain ±0″.00149.

The residuals corresponding to the final elements are given in columns five and six of the following table.

Date	θ	ρ	Prec.	$\theta_o - \theta_c$	$\rho_o - \rho_c$	Observer
	°	″	°	°	″	
1783.29	270 ±	7.93	+1.01	0 ±	−0.44	H 1*n*
1783.68	283.0	.	1.00	+12.9	.	H 1*n*
1819.84	267.1	6.31	0.63	+ 0.8	+ .39	Σ 1*n*
1821.08	266.8	5.94	0.61	+ 0.6	+ .07	Σ 1*n*
1831.40	264.4	4.62	0.50	+ 0.1	− .54	Σ 2*n*

Date	θ	ρ	Prec.	$\theta_o - \theta_c$	$\rho_o - \rho_c$	Observer
	°	″	°	°	″	
1832.10	267.3	5.0	0.49	+ 3.1	− .1	*h* 1*n*
1832.87	262.8	4.56	0.49	− 1.2	− .51	Σ 2*n*
1835.27	262.4	5.0	0.47	− 0.7	+ .1	Smyth 1*n*
1838.41	262.0	4.46	0.43	− 0.8	− .25	Σ 6*n*
1841.20	262.8	4.17	0.40	+ 0.7	+ .06	Dawes 2*n*
1841.25	266.2	*4.22	0.40	− 4.2	− .31	Challis and Glaisher 2*n*
1842.35	260.4	4.42	0.39	− 1.3	− .04	OΣ 3*n*
1842.49	261.6	4.36	+0.39	− 0.1	− .09	Kaiser 1*n*
1842.88	261.8	4.60	0.38	+ 0.2	+ .18	Maedler 2*n*
1850.27	258.6	4.00	0.31	− 1.4	+ .05	Dawes 3*n*
1852.88	257.5	3.80	0.28	− 0.8	+ .02	OΣ 2*n*
1852.41	252.9	3.62	0.29	− 5.6	− .19	Maedler
1854.26	258.3	3.61	0.27	+ 0.5	− .09	Morton
1854.84	256.0	3.48	0.26	− 1.6	− .18	Dawes 2*n*
1855.64	258.3	*3.70	0.25	+ 1.1	+ .09	Δ 12*n*
1856.24	257.2	3.41	0.23	+ 0.2	− .16	Secchi 3*n*
1861.47	251.9	3.49	0.19	+ 2.6	+ .24	Maedler 4*n*
1863.19	253.5	3.27	0.18	+ 0.1	+ .12	Δ 8*n*
1865.77	250.5	3.08	0.15	− 1.6	+ .09	Engel. 2*n*
1865.81	252.7	3.21	+0.15	+ 0.6	+ .22	Δ 8*n*
1866.10	261.8	3.51	0.15	+10.0	+ .54	Barclay 1*n*
1869.42	248.2	3.17	0.11	− 1.4	+ .39	OΣ 2*n*
1870.69	258.0	2.52	0.10	+ 9.3	− .19	Barclay 3-2*n*
1872.42	246.8	2.82	0.08	− 0.6	+ .21	Δ 4*n*
1872.78	247.7	3.08	0.08	+ 0.6	+ .49	Wilson 4*n*
1875.19	245.7	2.77	0.05	− 0.1	+ .32	Gledhill 3*n*
1876.59	243.9	2.7	0.04	+ 0.3	+ .3	Pritchard 2*n*
1876.84	244.8	2.64	0.03	+ 1.4	+ .28	Δ 3*n*
1878.38	240.4	2.70	0.02	− 1.4	+ .42	OΣ 2*n*†
1879.17	239.8	2.67	0.01	− 1.1	+ .43	Doberck 2*n*
1879.32	244.1	2.42	+0.01	+ 3.3	+ .19	Hall 5*n*
1880.35	239.2	2.62	−0.00	− 0.4	+ .44	Seabroke 3*n*
1881.09	238.3	2.40	−0.01	− 0.4	+ .25	Bigourdan 1*n*
1882.86	238.7	2.65	−0.03	+ 2.2	+ .59	Engel. 7*n*
1883.03	236.6	2.13	−0.03	+ 0.4	+ .08	Seabroke 15*n*
1887.38	231.0	2.13	−0.08	+ 1.1	+ .28	HΣ 1*n*
1889.27	224.4	1.95	−0.10	− 1.2	+ .18	Hall 3*n*
1897.29	208.7	1.24	−0.18	− 1.1	− .28	Leavenworth 2*n*
1897.38	216.6	1.58	−0.18	+ 7.1	+ .06	Brown 1*n*
1898.65	209.4	1.32	−0.19	+ 2.9	+ .18	Doolittle 4*n*
1899.32	203.9	1.32	−0.20	− 0.8	+ .16	Brown 6*n*
1905.23	190.1	1.28	−0.26	+ 0.9	− .17	β 2*n*
1908.22	176.3	1.04	−0.29	− 5.0	− .42	Biesbroeck 2*n*
1909.37	174.1	1.02	−0.31	− 4.2	− .46	Doberck 3-1*n*
1912.09	147.8	1.08	−0.33	−23.7	− .45	Aitken 1*n*

* These distances are incorrectly quoted in Lewis.

† In forming the mean Lewis includes the discordant measure 253°.2, 2″.04, which is marked "Uncertain" in OΣ. This measure is not here included.

An examination of the residuals of column six indicates clearly a definite curvature of path, the long series of positive residuals from 1861 to 1889 being especially noteworthy. If we apply test (*b*), above, we find, upon excluding the first observation of Σ, in which the angle is evidently slightly too large and in which from the position of the path a small change in angle produces a large displacement, a definite and quite regular increase of the velocity. The average value prior to 1873.23 is 0″.0605 and the average since that date is 0″.0760; the whole increase is from 0″.0478, in 1835, to 0″.0888 in 1905. Throughout the investigation we have omitted the measure of Aitken, as this, very unfortunately, is the result of but a single night.

σ^2 *Ursæ Majoris* is one of the standard stars of the *American Ephemeris*, its mean position being there published to $0^s.001$ in R. A. and to 0″.01 in Decl. If the conclusion reached in this paper is a true one, however, it is evident that this object is very ill suited for a standard star: the location of the center of gravity about which it and the companion are moving is, of course, as yet wholly impossible, since nothing in the motion thus far gives any hint as to the true size of the orbit.

The following values have been found for the proper-motion of *A* from meridian circle observations:

0″.064	in 179°.0	(Auwers)
0 .056	in 178 .5	(Newcomb)
0 .070	in 179 .5	(Boss)

From the investigation above, the relative motion of *A* with respect to *B*, so far as this can be represented by a straight line, is

0″.0679 in 281°.04 (Micrometric).

The Flower Observatory, February 4, 1918.

MICROMETRICAL MEASURES OF DOUBLE STARS,

MADE WITH THE 10½-INCH REFRACTOR OF THE UNIVERSITY OF MINNESOTA,

By WM. O. BEAL.

The following measures of miscellaneous double stars have been made as opportunity offered when the telescope was not being used on our main observing program. The star places are for 1880.

136 β 301 $0^h\,43^m\,21^s$ $-22°\,3'$

A and *C*

1900 +	θ	ρ	Mags.		Remarks	
	°	″				
16.850	295.8	10.33	8.3	8.9		
16.880	298.8	11.17	8.2	9.2		
16.886	297.1	11.08	8.5	9.8		
17.844	298.8	10.82	8.7	10.0		
17.874	298.3	10.17	8.8	9.9		
17.27	297.8	10.71	8.5	9.6	5*n*	(1)

166 β 734 $0^h\,46^m\,47^s$ $-24°\,40'$

16.880	347.2	10.93	6.4	11.2		
16.886	346.4	11.23	6.5	11.0		
16.919	346.4	12.06	6.4	10.8		
17.874	347.0	12.38	6.5	10.5		(2)
17.973	346.7	11.31	6.5	11.5		
17.31	346.7	11.58	6.5	11.0	5*n*	(1)

587 β 397 $1^h\,0^m\,54^s$ $+46°\,12'$

A and *B*

1900 +	θ	ρ	Mags.		Remarks	
	°	″				
16.886	143.4	8.80	7.8	10.0		
16.919	142.8	9.00	7.7	10.2		
16.924	142.8	8.56	7.7	10.3		
17.844	144.9	8.46	7.8	10.0		
17.871	141.2	9.16	8.7	10.9		
17.29	143.0	8.80	7.9	10.3	5*n*	(1)

923 β 736 $1^h\,39^m\,38^s$ $+38°\,20'$

A and *C*

16.919	115.5	12.54	8.5	8.8		
16.924	116.5	12.40	8.5	8.9		
17.871	116.0	12.50	8.6	9.0		
17.874	116.3	12.17	8.6	8.8		
17.910	116.3	12.56	8.8	9.3		
17.50	116.1	12.43	8.6	9.0	5*n*	(1)

1122 *Castor* $7^h\,26^m\,57^s$ $+32°\,9'$

16.188	217.1	5.10	2.7	3.2		
16.319	217.5	5.43	2.7	3.2		
16.344	217.8	5.42	2.0	3.0		
16.352	218.6	5.43	2.5	3.2		
16.30	217.8	5.35	2.5	3.1	4*n*	(3)

Espin 592 $8^h\,4^m\,56^s$ $+41°\,55'$

1900 +	θ	ρ	Mags.		Remarks	
	°	″				
17.242	327.3	3.04	8.5	11.0		
17.269	329.5	3.08	8.5	10.5		
17.275	326.6	3.14	8.4	10.4		
17.26	327.8	3.09	8.5	10.6	3*n*	

Espin 426 $8^h\,17^m\,33^s$ $+28°\,51'$

17.283	285.3	4.35	9.0	9.5		
17.305	286.4	4.39	9.4	9.8		
17.343	282.4	4.37	9.5	9.8		
17.31	284.7	4.37	9.3	9.7	3*n*	

Espin 596 $8^h\,39^m\,42^s$ $+45°\,58'$

17.242	201.7	3.25	8.7	10.6		
17.269	201.6	3.22	8.5	10.7		
17.275	201.5	3.17	8.7	10.3		
17.26	201.6	3.21	8.6	10.5	3*n*	

Espin 180 $10^h\,1^m\,31^s$ $+36°\,10'$

17.242	357.9	7.94	8.7	10.6		
17.266	358.2	7.55	8.9	10.7		
17.275	359.8	9.14	9.1	11.3		(2)
17.280	356.4	7.50	9.2	10.8		
17.27	358.1	8.03	9.0	10.8	4*n*	

5365 OΣ 215 $10^h\,9^m\,44^s$ $+18°\,20'$

17.376	200.8	1.11	6.9	7.2		
17.392	201.7	0.90	6.9	7.5		
17.406	202.2	1.19	7.0	7.4		
17.39	201.6	1.07	6.9	7.4	3*n*	(4)

5508 Σ 1457 $10^h\,32^m\,28^s$ $+6°\,21'$

17.373	326.6	1.55	7.5	8.1		
17.376	320.0	1.46	7.5	8.1		
17.392	321.4	1.36	7.5	8.2		
17.463	316.2	1.25	7.2	7.7		
17.466	321.9	1.37	7.5	8.1		
17.41	321.2	1.40	7.4	8.0	5*n*	(4)

5560 OΣ 229 $10^h\,41^m\,8^s$ $+41°\,46'$

17.376	308.7	0.83	7.3	7.6		
17.392	311.1	0.82	7.5	8.0		
17.420	315.2	0.90	6.9	7.3		
17.439	311.5	0.63	6.8	7.1		
17.466	314.8	0.94	6.8	7.1		
17.42	312.3	0.82	7.1	7.4	5*n*	(5)

Espin 305 $11^h\,10^m\,52^s$ $+35°\,8'$

1900 +	θ	ρ	Mags.		Remarks	
	°	″				
17.302	34.2	4.74	8.7	10.3		
17.354	32.2	3.78	9.2	9.9		
17.373	31.9	4.46	8.9	9.6		
17.34	32.8	4.33	8.9	9.9	3*n*	

6053 Σ 1606 $12^h\,4^m\,44^s$ $+40°\,34'$

17.392	321.8	0.94	6.4	7.0		
17.420	326.3	1.00	7.0	7.7		
17.439	324.7	0.86	6.3	6.8		
17.455	324.5	0.90	6.5	7.2		
17.466	326.8	0.98	6.3	7.0		
17.43	324.8	0.94	6.5	7.1	5*n*	(4)

6243 γ *Virginis* $12^h\,35^m\,37^s$ $-0°\,47'$

14.348	325.2	6.08	. .	. . .		
16.270	324.8	5.96	3.0	3.0		
16.273	324.2	6.07	3.0	3.0		
16.308	324.1	6.08	3.0	3.0		
17.376	324.3	6.20	3.2	3.2		
17.417	321.7	6.03	3.0	3.2		
17.452	323.0	5.90	. .	. .		
17.455	323.5	5.94	. .	. . .		
16.61	323.8	6.03	3.0	3.1	8*n*	(6)

6295 Σ 1686 $12^h\,46^m\,59^s$ $+15°\,41'$

14.372	186.0	5.84	. .	. . .		
14.378	187.6	5.50	. .	. . .		
16.270	187.8	6.03	8.6	9.0		
16.273	188.3	5.53	8.2	8.5		
16.308	187.3	5.74	8.0	8.2		
15.52	187.4	5.73	8.3	8.6	5*n*	(7)

Jon. 434 $13^h\,2^m\,21^s$ $-0°\,13'$

17.370	328.9	3.48	9.0	9.4		
17.455	323.4	3.60	9.2	9.5		
17.466	325.3	3.81	9.3	9.6		
17.43	325.9	3.63	9.2	9.5	3*n*	

6415 OΣ 261 $13^h\,6^m\,23^s$ $+32°\,43'$

14.367	345.8	1.76	. .	. .		
16.319	343.3	1.61	6.7	7.1		
16.338	342.7	1.83	6.5	6.8		
16.344	345.2	1.68	7.5	8.3		
17.420	346.5	1.81	6.8	7.3		
17.439	343.5	1.69	6.2	6.7		
17.452	346.7	1.72	6.3	6.7		
17.455	343.5	1.39	6.3	6.5		
17.464	342.1	1.56	6.8	7.3		
16.733	344.4	1.67	6.6	7.1	9*n*	(4)

6566 Σ 1768 $13^{h}\ 32^{m}\ 7^{s}$ $+36°\ 54'$

1900 +	θ	ρ	Mags.		Remarks
	°	″			
17.472	128.1	1.27	5.6	8.7	
17.477	124.1	1.16	5.5	8.5	
17.499	125.5	1.20	5.7	8.7	
17.505	127.0	1.36	5.8	8.8	
17.595	125.8	1.29	5.5	8.2	
17.51	126.2	1.26	5.6	8.6	5*n*

6626 Σ 1783 $13^{h}\ 40^{m}\ 56^{s}$ $+11°\ 38'$

1900 +	θ	ρ	Mags.		Remarks
14.372	50.6	2.40		. .	
16.319	4.98	2.04	7.8	10.2	
16.338	5.00	1.64	8.0	11.0	
16.341	46.8	1.70	8.2	10.8	
15.84	49.3	1.94	8.0	11.0	4*n*

6641 Σ 1785 $13^{h}\ 43^{m}\ 38^{s}$ $+27°\ 35'$

1900 +	θ	ρ	Mags.		Remarks
17.420	355.1	1.28	7.0	7.4	
17.439	354.7	1.32	6.8	7.2	
17.452	355.3	1.29	6.9	7.2	
17.464	352.4	1.27	6.8	7.4	
17.466	352.3	1.16	6.9	7.3	
17.45	354.0	1.26	6.9	7.3	5*n*

7195 *β* 352 $15^{h}\ 10^{m}\ 42^{s}$ $-26°\ 33'$

1900 +	θ	ρ	Mags.		Remarks	
17.472	66.0	14.42	8.3	10.2		
17.477	66.4	14.48	8.6	10.5		
17.513	66.3	14.69	8.3	9.7		
17.49	66.2	14.53	8.4	10.1	3*n*	(1)

7211 Lv 6 $15^{h}\ 13^{m}$ $-26°\ 35'$

1900 +	θ	ρ	Mags.		Remarks
17.472	29.7	17.32	8.0	10.5	
17.477	29.1	17.21	8.7	10.6	
17.513	29.3	17.28	8.6	10.3	
17.49	29.4	17.27	8.4	10.5	3*n*

A.G. Camb. 7446 $15^{h}\ 56^{m}\ 10^{s}$ $28°\ 27'$

1900 +	θ	ρ	Mags.		Remarks	
17.466	225.6	11.87	8.5	9.7		
17.505	226.0	12.08	8.8	10.7		
17.526	227.5	12.31	8.6	10.0		
17.50	226.4	12.09	8.6	10.1	3*n*	(8)

7487 Σ 1998 $15^{h}\ 57^{m}\ 46^{s}$ $-11°\ 3'$

A and *B*

1900 +	θ	ρ	Mags.		Remarks	
17.540	173.6	0.82	4.8	4.8		
17.554	174.6	0.91	5.0	5.0		
17.570	175.4	0.91	5.3	5.3		
17.587	174.5	0.83	5.3	5.3		
17.617	176.3	0.87	5.2	5.4		
17.57	174.9	0.87	5.1	5.1	5*n*	(9)

AB and *C*

1900+	θ	ρ	Mags.		Remarks
	°	″			
17.540	60.0	7.47	4.8	9.5	
17.554	58.8	8.02	5.2	9.5	(2)
17.570	60.2	7.40	5.3	9.7	
17.587	59.4	7.33	5.3	8.6	
17.617	59.4	7.63	5.2	8.0	
17.57	59.6	7.57	5.2	9.1	5*n*

7563 Σ 2032 $16^{h}\ 10^{m}\ 11^{s}$ $+34°\ 10'$

A and *B*

1900+	θ	ρ	Mags.		Remarks
17.436	218.5	5.07	5.0	6.0	
17.466	217.6	5.40	5.2	6.2	
17.499	217.7	5.26	5.3	6.7	
17.516	217.8	5.02	5.3	6.3	
17.535	218.2	5.49	5.8	6.6	
17.49	218.0	5.25	5.3	6.4	5*n*

A and *D*

1900+	θ	ρ	Mags.		Remarks
17.436	85.7	66.55	5.0	8.5	
17.466	85.5	66.62	5.2	8.7	
17.499	84.9	66.43	6.7	9.5	
17.516	85.1	67.80	5.3	9.7	
17.535	85.2	66.69	5.8	10.2	
17.49	85.3	66.82	5.6	9.3	5*n*

8038 Σ 2173 $17^{h}\ 24^{m}\ 14^{s}$ $-0°\ 58'$

1900+	θ	ρ	Mags.		Remarks
17.436	156.2	0.69	5.8	6.1	
17.472	158.9	0.90	5.7	6.1	
17.505	156.4	1.01	5.7	6.0	
17.562	158.7	0.75	6.3	6.3	
17.606	156.2	0.81	6.2	6.4	
17.52	157.3	0.83	5.9	6.2	5*n*

8303 Σ 2262 $17^{h}\ 56^{m}\ 33^{s}$ $-8°\ 11'$

1900+	θ	ρ	Mags.		Remarks
17.436	263.1	1.98	5.1	5.5	
17.472	260.7	2.03	5.1	5.5	
17.540	262.6	2.04	5.8	6.2	
17.554	261.3	2.17	5.0	5.8	
17.562	263.8	1.95	4.8	5.5	
17.51	262.3	2.03	5.2	5.7	5*n*

8310 Σ 2272 $17^{h}\ 59^{m}\ 23^{s}$ $+2°\ 33'$

1900+	θ	ρ	Mags.		Remarks	
17.570	137.1	5.15	4.3	7.8		
17.587	137.0	4.94	4.5	7.0		
17.589	137.9	5.05	4.2	8.0		
17.595	137.1	5.14	4.2	7.0		
17.606	135.3	5.01	4.5	6.3		
17.59	136.9	5.06	4.3	7.2	5*n*	(10)

8619 β 419 $18^h\ 25^m\ 42^s$ $-7°\ 55'$

1900 +	θ	ρ	Mags.		Remarks	
	°	″				
16.585	41.2	1.13	8.2	8.9		
16.603	47.9	1.12	8.5	9.2		
16.774	43.9	1.16	8.2	9.8		
16.65	44.3	1.14	8.3	9.3	3*n*	(11)

8663 OΣ 358 $18^h\ 30^m\ 32^s$ $+16°\ 53'$

17.570	187.2	1.68	7.5	7.7		
17.587	187.7	1.90	7.7	7.9		
17.589	187.5	1.87	7.8	8.0		
17.595	187.7	1.87	6.8	7.0		
17.606	187.7	1.87	7.2	7.2		
17.59	187.6	1.84	7.4	7.6	5*n*	(3)

A.G. Camb. 10992 $20^h\ 7^m\ 27^s$ $+29°\ 1'$

17.765	304.9	3.54	8.5	9.0		
17.789	303.3	3.89	8.4	9.0		
17.877	304.8	3.69	8.5	9.1		
17.81	304.3	3.71	8.5	9.0	3*n*	

10692 Lv 9 $20^h\ 57^m\ 25^s$ $+38°\ 45'$

16.817	195.2	2.14	9.2	10.5		
16.845	190.8	2.20	9.8	10.6		
16.880	197.8	2.49	9.8	11.2		
17.877	190.3	1.63	9.5	11.2		
17.10	193.5	2.12	9.6	10.9	4*n*	(1)

10732 61 *Cygni* $21^h\ 1^m\ 14^s$ $+38°\ 8'$

15.749	130.1	23.76	..	...		
15.771	130.6	24.12	5.3	5.9		(2)
15.785	129.9	23.55	5.3	5.5		
15.810	130.1	23.66	5.3	6.0		
15.815	130.3	23.74	5.3	5.6		
15.826	129.9	23.72	5.3	6.3		
15.79	130.2	23.73	5.3	5.9	6*n*	(3)

10997 β 369 $21^h\ 22^m\ 31^s$ $+52°\ 14'$

A and *B*

16.856	29.5	16.58	8.5	11.7		
16.869	30.4	15.89	7.8	11.2		
16.899	32.4	17.32	7.7	11.2		
17.877	29.7	17.15	7.8	11.6		
17.12	30.5	16.74	8.0	11.4	4*n*	(1)

A and *C*

16.856	63.5	50.73	8.5	11.4		
16.861	62.2	50.74	7.8	11.2		
16.869	62.0	51.20	7.8	11.1		
17.877	62.7	52.07	7.8	11.4		
17.12	62.6	51.18	8.0	11.3	4*n*	(1)

11058 β 370 $21^h\ 28^m\ 15^s$ $+52°\ 13'$

1900+	θ	ρ	Mags.		Remarks	
	°	″				
16.860	325.8	3.54	8.5	9.7		
16.899	327.8	3.40	8.5	9.5		
16.938	326.0	3.61	8.5	9.0		
17.850	325.6	3.01	8.8	10.0		
17.858	325.6	3.27	8.0	9.0		
17.28	326.2	3.37	8.5	9.4	5*n*	(1)

11121 β 371 $21^h\ 32^m\ 58^s$ $+58°\ 10'$

16.856	2.5	8.53	8.0	10.6		
17.847	0.4	8.39	8.3	10.7		
17.858	2.9	8.79	8.5	11.2		
17.877	3.0	8.70	8.4	10.4		
17.61	2.2	8.60	8.3	10.7	4*n*	(1)

11735 β 380 $22^h\ 22^m\ 2^s$ $+49°\ 6'$

A and *B*

16.938	323.2	25.51	7.3	11.1		
17.847	322.5	25.17	8.6	11.4		
17.858	324.0	24.73	8.6	11.3		
17.877	322.6	24.64	8.7	11.5		
17.63	323.1	25.01	8.3	11.3	4*n*	(1)

A and *C*

16.899	134.5	36.31	7.2	7.5		
16.938	134.5	36.25	7.3	7.6		
17.847	134.2	36.38	8.6	8.7		
17.858	134.4	36.57	8.6	8.3		
17.877	134.4	36.53	8.7	8.5		
17.48	134.4	36.41	8.1	8.1	5*n*	(1)

11713 Σ 2909 $22^h\ 22^m\ 39^s$ $-0°\ 38'$

17.850	305.5	2.83	3.7	4.0		
17.858	305.6	2.96	4.0	4.3		
17.861	305.9	2.90	3.8	4.2		
17.871	304.6	2.99	3.8	4.0		
17.910	305.4	2.87	4.0	4.0		
17.87	305.4	2.91	3.9	4.1	5*n*	

11752 β 478 $22^h\ 23^m\ 8^s$ $-7°\ 56'$

A and *C*

16.930	238.7	29.53	8.8	9.2		
17.877	237.8	29.04	9.1	9.5		
17.910	236.8	29.39	9.0	9.6		
17.57	237.8	29.32	9.0	9.4	3*n*	(1)

11866 Σ 2928 23h 33m 10s −13° 14′

1900+	θ	ρ	Mags.		Remarks
14.843	127.0	4.18	. .	. . .	
15.769	128.0	3.79	8.0	8.1	
15.785	127.8	3.89	8.0	8.0	
15.807	126.9	3.73	8.0	8.2	
17.871	127.6	3.92	8.5	8.8	
16.02	127.5	3.90	8.1	8.3	5*n*

12201 β 385 23h 4m 31s +31° 50′

AB and *C*

1900+	θ	ρ	Mags.		Remarks	
16.861	76.9	58.49	7.5	8.9		
16.899	77.0	58.25	7.5	9.0		
16.919	76.9	58.44	6.8	8.8		
17.839	77.2	58.43	6.9	9.5		
17.841	76.9	58.28	7.5	9.2		
17.27	77.0	58.38	7.2	9.1	5*n*	(1)

A.G. Leipzig I 9311 23h 20m 37s +14° 29′

1900+	θ	ρ	Mags.		Remarks
17.874	252.8	6.96	9.3	11.5	
17.973	252.2	7.80	8.7	11.7	
18.000	250.2	7.74	9.0	11.3	
17.95	251.7	7.50	9.0	11.5	3*n*

12435 β 387 23h 28m 8s −10° 22′

1900+	θ	ρ	Mags.		Remarks	
16.886	72.7	5.44	7.8	9.8		
16.919	69.9	6.13	8.5	9.6		
16.930	70.7	5.69	8.3	9.5		
17.861	72.9	6.70	. .	. . .		
17.871	68.9	5.80	8.3	10.3		
17.29	71.0	5.95	8.2	9.8	5*n*	(1)

12517 OΣ 503 23h 35m 59s +19° 38′

1900+	θ	ρ	Mags.		Remarks	
	°	″				
14.794	134.3	1.59	. .	. . .		
15.801	129.9	1.58	7.2	8.2		
15.804	132.6	1.53	7.2	7.8		
15.806	129.9	1.47	7.2	7.8		
17.860	129.0	1.16	7.8	8.5		
17.871	127.3	1.34	7.8	8.5		
16.32	130.5	1.44	7.5	8.2	6*n*	(1)

REMARKS

(1) No relative motion since discovery.

(2) Seeing poor.

(3) In good accord with recent measures.

(4) Motion apparently rectilinear.

(5) Slow motion in angle.

(6) Comparison with DOBERCK's ephemeris in *A. N.* 3364 gives O — C, −1°.5, −″.23. Recent observations seem to indicate that the period of this binary is several years less than that used in computing DOBERCK's ephemeris.

(7) Distance may be increasing.

(8) In *A. J.* 591 MILLER gives distance as 5″.79 which is probably just half what it should be.

(9) Comparison with AITKEN's ephemeris in Lick Pub., Vol. XII gives O — C, +0°.2, −″.17.

(10) Comparison with LOHSE's ephemeris in *Potsdam Pub.*, Vol. XX gives O — C, −0°.9, −″.03.

(11) Apparently a slow motion in both angle and distance.

University of Minnesota, Minneapolis, Minn., January 26, 1918.

NEW ASTRONOMICAL WORK.

The Rumford Spectroheliograph of the Yerkes Observatory, by GEORGE E. HALE and FERDINAND ELLERMAN. *Publications of the Yerkes Observatory*, Vol. III, Part I.

The Spectrum of the High Potential Discharge between Metallic Electrodes in Liquids and in Gases at High Pressures, by GEORGE E. HALE and NORTON A. KENT. *Publications of the Yerkes Observatory*, Vol. III, Part II.

Stellar Parallaxes Derived from Photographs made with the Forty-inch Refractor. Publications of the Yerkes Observatory, Vol. IV, Part I.

Catalogue of Proper-Motion Stars, Part III, by JERMAIN G. PORTER. *Publications of the Cincinnati Observatory*, No. 18. Cincinnati. 1917.

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MEASURES OF DOUBLE STARS,

By S. W. BURNHAM.

Some months ago DR. BURNHAM placed in my hands his ledgers of double star observations with the request that I extract the unpublished measures and prepare them for print. The measures are for the most part of wide pairs and were made with the view of determining proper-motions. It was my intention to make comparisons with prior measures and to make the computations where material was available. Continued absence from my desk at the Dearborn Observatory and the uncertainty of the time of my return to it lead me to publish the observations without notes. At some future day the omission may be remedied. The labor of preparing the observations for print devolved on MISS LUELLA SAYER, to whom I am indebted.

PHILIP FOX, *Maj. Inf. R. C.*

No.		α 1880	δ 1880	Date	Angle	Distance	Mag.	n	
		h m s	° ′		°	″			
135	Σ 25	0 12 30	+15 20	1913.838	201.61	173.66	8.5 — 11.6	3	*AB* and *C*
...	Anon.	0 21 30	+60 21	1912.428	329.10	36.20	10.6 — 13.1	2	....
305	*Andromedæ* 112 ..	0 28 44	+36 10	1913.621	123.13	24.88	6.8 — 12.8	3	....
316	*H* 1986	0 29 12	+84 5	1912.780	60.60	40.25	7.0 — 7.5	3	*A* and *B*
...	....	....	......	1912.780	186.84	55.72	7.0 — 10.2	3	*A* and *C*
363	*Andromedæ* 125 ..	0 33 59	+23 24	1912.780	205.00	16.40	6.7 — 8.6	3	*A* and *B*
..	....	....	......	1912.780	230.07	42.90	....	3	*A* and *C*
..	....	....	......	1912.780	244.24	28.97	....	3	*B* and *C*
368	Σ 49	0 34 42	− 7 53	1912.786	321.90	6.56	6.7 — 10.0	3	....
374	OΣ 18	0 36 12	+ 3 31	1913.838	270.91	42.66	— 12.5	3	*A* and *C*
482	*Andromedæ* 36 ...	0 48 32	+22 59	1913.616	232.26	133.25	— 11.5	3	....
...	39 *Ceti*	1 10 31	− 3 8	1913.453	84.30	177.57	5.7 — 11.4	3	....
798	*Andromedæ* 219 ..	1 25 55	+35 14	1911.360	195.90	24.67	....	3	*A* and *C*
...	....	....	......	1911.565	191.30	29.32	....	3	*A* and *D*
819	*Cassiopeiæ* 40	1 28 57	+72 26	1913.876	236.53	53.35	— 11.5	3	....
860	Σ 142	1 33 28	+14 39	1911.644	181.94	102.31	....	3	*A* and *C*
862	Σ 143	1 33 32	+33 44	1913.901	319.48	37.37	7.7 — 9.0	3	*A* and *B*
...	....	....	......	1913.901	136.65	70.82	7.7 — 9.6	3	*A* and *C*
913	β 6	1 38 43	− 7 22	1913.736	84.29	92.80	6.4 — 10.9	3	*A* and *C*
929	Σ 160	1 40 17	− 3 0	1913.251	268.80	9.55	....	2	*A* and *B*
.	....	....	......	1913.073	241.00	28.64	10.8 — 11.0	3	*C* and *D*
...	....	....	......	1912.736	162.38	181.74	....	2	*A* and *C*
946	β 510	1 42 4	+15 43	1913.685	326.88	53.29	....	3	*A* and *C*
950	*H* 644	1 42 22	+ 7 5	1913.850	279.26	17.31	....	3	*A* and *B*
...	....	....	......	1913.900	225.95	126.74	....	2	*A* and *C*
989	*Andromedæ* 55 ...	1 46 6	+40 8	1913.901	365.40	59.62	....	3	....
998	Σ 182	1 47 58	+60 42	1913.622	65.09	28.35	7.0 — 12.5	3	*A* and *C*

No.		α 1880	δ 1880	Date	Angle	Distance	Mag.	*n*	
		h m s	° ′		°	″			
1027	Σ 185..........	1 51 1	+74 55.	1913.577	174.11	116.31	— 9.0	3	*A* and *BD* 74° (92)
1034	58 *Ceti*.........	1 51 43	− 2 39	1913.876	197.40	150.01	— 8.5	3	*A* and *SD* −2°(329)
1268	*H III* 80.......	2 20 18	−15 53	1913.876	295.20	11.84	6.2 —	3	*A* and *B*
....	....	....	......	1913.876	29.65	105.56	....	3	*A* and *SD* −15°(427)
1347	*H* 2152.........	2 31 53	+19 12	1913.958	58.75	42.90	....	1	....
1418	β 9.............	2 39 40	+35 3	1913.960	138.27	31.56	— 13.2	2	*A* and *C*
1448	π *Arietis*........	2 42 36	+16 58	1913.960	110.83	24.95	— 10.5	2	*A* and *C*
....	*Puiseux*........	2 45 34	+22 37	1912.673	300.79	161.83	....	4	*A* and *D*
....	....	....	......	1912.673	289.64	100.95	....	4	*D* and *E*
1468	τ *Persei*.........	2 45 45	+52 16	1912.766	106.07	51.02	....	3	....
1471	20 *Persei*.......	2 46 8	+37 51	1913.750	49.39	56.16	....	1	*AB* and *D*
1492	Σ 328..........	2 49 48	+44 2	1912.780	300.80	21.61	....	3	*A* and *B*
....	....	......	......	1912.780	90.84	48.95	— 11.7	3	*A* and *C*
1512	ε *Arietis*........	2 52 21	+20 52	1912.798	191.62	145.42	4.6 — 12.7	3	*AB* and *C*
1526	OΣ 49..........	2 53 47	+17 32	1913.494	206.42	146.07	— 12.0	3	*A* and *C*
1565	β *Persei*	3 0 22	+40 30	1912.878	155.49	58.48	....	2	*A* and *B*
....	....	....	......	1912.878	145.15	67.41	....	2	*A* and *C*
....	....	....	......	1913.190	192.40	81.57	....	5	*A* and *D*
1595	Σ 343..........	3 4 38	+83 37	1912.780	325.20	28.19	....	3	*A* and *B*
...	....	....	......	1912.780	295.21	57.85	— 12.5	3	*B* and *C*
1827	Σ 434..........	3 36 6	+38 0	1913.914	86.63	30.89	7.0 — 7.8	3	*A* and *B*
1902	*H* 666..........	3 43 15	+ 9 3	1913.187	18.01	30.85	6.5 —	3	....
1924	30 *Eridani*......	3 46 47	− 5 43	1913.083	134.20	8.29	....	4	....
1939	32 *Eridani*......	3 48 16	− 3 19	1913.876	4.63	165.74	— 10.6	3	*A* and *C*
1940	β 540...........	3 48 21	+31 48	1913.942	57.98	57.27	8.0 — 8.0	1	*A* and *C*
1950	ε *Persei*.........	3 49 48	+39 40	1912.798	11.03	78.30	2.9 — 14.0	3	*A* and *C*
1996	Ho 221.........	3 55 10	+54 45	1913.716	276.84	136.16	7.0 — 10.8	4	*A* and *C*
2019	β 1277..........	3 58 15	+28 4	1912.798	69.83	54.40	8.0 — 10.6	3	*A* and *C*
2084	47 *Tauri*........	4 7 25	+ 8 58	1913.960	225.59	31.17	....	2	*A* and *C*
2093	OΣ 77..........	4 8 19	+31 24	1913.704	41.98	56.05	....	3	*AB* and *C*
..	....	....	......	1913.704	313.79	128.44	....	3	*AB* and *D*
...	54 *Persei*	4 12 37	+34 17	1913.958	312.72	109.97	— 13.0	1	....
...	*Groom.* 848	4 32 42	+75 4	1913.968	60.10	96.88	6.0 — 12.0	1	....
...	4 *Camelop.*......	4 38 0	+56 33	1913.697	197.30	13.41	5.4 — 13.2	3	*A* and *B*
....	....	.....	......	1913.666	218.87	102.41	— 12.0	3	*A* and *C*
....	*Pi* 170..........	4 21 2	+63 18	1913.666	350.53	115.40	5.9 — 10.4	3	....
2459	ε *Aurigæ*........	4 53 22	+43 39	1913.083	275.23	43.07	— 12.0	4	*A* and *C*
....	....	....	......	1913.156	47.76	207.58	— 9.5	3	*A* and *BD* 43° (1168)
2584	ρ *Orionis*........	5 7 1	+ 2 43	1913.513	155.18	182.36	— 11.9	3	*A* and *C*
2639	τ *Orionis*........	5 11 47	− 6 58	1913.404	249.97	34.88	....	4	*A* and *B*
..	....	....	......	1913.404	60.22	36.19	....	4	*A* and *D*
....	16 *Camelop.*.....	5 13 11	+57 26	1913.226	218.97	106.20	5.3 — 13.0	3	....
...	*B.D.* 64° (532)...	5 19 57	+64 13	1913.328	48.98	142.59	— 10.0	4	....
2735	ψ^2 *Orionis*... ..	5 20 33	+ 2 59	1912.874	195.91	83.39	4.7 — 13.1	3	*A* and *C*
2783	33 *Orionis*	5 24 57	+ 3 12	1912.866	51.64	95.70	5.9 — 13.6	3	*A* and *C*
2807	Σ 735..........	5 27 2	− 6 35	1913.953	352.11	43.53	8.5 — 9.0	3	*A* and *B*

No.		α 1880	δ 1880	Date	Angle	Distance	Mag.	*n*	
		h m s	° '		°	"			
....	....	....	......	1913.960	284.19	146.25	9.0 — 10.9	2	*B* and *C*
2813	α *Leporis*	5 27 24	−17 55	1913.960	156.54	35.80	— 12.9	2	*A* and *D*
....	....	....	......	1913.960	185.65	91.41	— 12.7	2	*A* and *C*
....	P. M. Star	6 19 10	+19 8	1913.395	222.08	90.77	10.2 — 13.0	4	....
3435	20 *Geminorum*	6 25 18	+17 52	1913.414	136.11	47.36	— 13.0	2	*B* and *C*
....	θ *Geminorum*	6 44 53	+34 6	1913.815	321.55	78.15	3.6 — 12.4	4	*A* and *B*
....	....	....	......	1913.815	185.43	102.08	— 11.3	4	*A* and *C*
3698	Σ 983	6 48 17	+34 37	1913.167	35.30	11.16	....	3	*A* and *B*
....	....	....	......	1913.167	193.10	23.05	....	3	*A* and *C*
....	*Nova Geminorum*	6 49 12	+32 15	1912.229	98.78	79.55	3.8 — 12.0	3	*A* and *C*
....	....	....	......	1912.245	16.20	11.84	....	2	*A* and *B*
3844	45 *Geminorum*	7 1 29	+16 7	1913.953	328.00	52.75	— 12.9	3	*A* and *C*
3853	Ho 519	7 2 14	+25 56	1913.950	84.94	109.64	....	2	*A* and *C*
....	....	....	......	1913.961	112.63	20.77	— 13.0	1	*A* and *B*
3862	τ *Geminorum*	7 3 30	+30 26	1913.950	342.26	58.66	— 12.9	2	*A* and *C*
4454	*H* 3308	8 2 21	+35 49	1913.452	267.30	48.00	— 10.7	2	*A* and *C*
4612	2 *Hydræ*	8 20 27	− 3 36	1913.558	5.34	71.58	....	2	....
4661	*H* 452	8 26 00	+29 52	1913.961	317.07	29.99	9.7 — 10.0	1	....
4662	Σ 3119	8 26 7	+ 8 54	1912.875	216.00	26.92	....	2	....
....	Espin	9 49 48	+51 0	1911.153	89.60	2.64	....	2	....
5595	Σ 1484	10 47 40	+46 6	1912.062	353.30	14.34	....	3	....
5691	*S* 621	11 3 57	+66 40	1914.217	44.32	69.43	....	2	....
....	Wolf	11 22 18	+ 8 19	1914.298	258.25	77.33	....	3	....
5949	Sh 132	11 46 35	+16 6	1914.217	14.21	38.95	....	2	*A* and *B*
...	....	....	......	1914.227	264.85	90.46	— 11.8	1	*A* and *C*
6180	17 *Comæ*	12 22 55	+26 35	1913.543	250.66	144.77	....	4	....
6534	*Virginis* 550	13 38 18	−12 36	1913.844	152.28	24.79	....	2	*AB* and *C*
6618	*Virginis* 86	13 39 33	−11 49	1913.844	163.90	26.41	....	2	*A* and *C*
6746	Σ 1808	14 4 44	+27 10	1913.327	118.45	48.26	— 12.2	2	*A* and *C*
6768	β 939	14 7 48	− 7 57	1913.844	281.01	87.62	....	2	....
6783	Σ 1823	14 9 57	+10 52	1913.672	230.77	63.39	— 12.2	3	*AB* and *D*
7241	12 *Ursæ Minoris*	15 17 9	+71 39	1913.831	133.11	55.61	....	4	*A* and *B*
....	....	....	......	1913.831	113.65	89.84	....	4	*A* and *C*
....	*υ Bootis*	15 27 19	+41 18	1913.672	89.13	91.59	5.1 — 13.0	3	....
7479	*H v* 75	15 56 5	+26 30	1913.845	110.75	48.32	....	2	....
....	*ϵ Ophiuchus*	16 11 58	− 4 23	1913.432	246.35	109.87	3.1 — 12.2	4	....
....	53 *Hercules*	16 48 25	+31 54	1913.378	62.74	66.14	5.6 — 12.3	3	....
....	*BD* 33° (2815)	16 56 57	+33 42	1910.397	314.00	153.60	9.0 — Neb.	1	....
....	27 *Draconis*	17 32 27	+68 13	1913.373	344.76	169.97	5.3 — 11.5	3	....
....	*i Hercules*	17 36 5	+46 4	1913.445	49.21	116.04	3.3 — 11.6	4	....
....	*ω Draconis*	17 37 39	+68 49	1913.372	277.57	72.00	5.0 — 13.3	3	....
8320	Σ 2271	17 57 41	+52 51	1913.720	18.17	167.34	— 12.4	3	*A* and *C*
....	*h* 3744	18 17 13	−23 16	1910.626	144.00	122.66	13.0 — 10.1	3	Neb. and ∗
8786	110 *Hereules*	18 40 30	+20 26	1913.441	81.75	62.12	....	4	*A* and *C*
8832	Σ 2399	18 43 45	+13 5	1913.467	69.49	41.78	— 12.0	3	*B* and *D*
8868	β *Lyræ*	18 45 39	+33 13	1913.373	317.88	66.61	Var.	3	*A* and *E*
....	....	....	......	1913.373	18.96	85.67	....	3	*A* and *F*
....	....	....	......	1913.471	247.04	46.36	....	2	*A* and *C*
....	*BD* 16° (3752)	19 2 54	+16 41	1911.302	275.68	120.03	5.5 — 9.5	1	*A* and *BD* 16°(3753)

No.		α 1880	δ 1880	Date	Angle	Distance	Mag.	*n*	
		h m s	° ′		°	″			
9416	9 *Vulpecula*	19 29 19	+19 31	1913.806	318.31	108.47	— 13.1	3	*A* and *C*
9444	*H v* 104	19 30 55	+15 37	1913.582	127.62	38.60	7.3 —	3	....
9464	Σ 2545	19 32 8	−10 26	1913.479	167.47	26.80	— 11.0	3	*A* and *C*
9605	δ *Cygni*	19 41 13	+44 50	1913.432	65.46	68.19	— 12.0	4	*A* and *C*
9619	Ho 114	19 41 59	+32 36	1913.467	199.55	31.18	....	3	*A* and *D*
10007½	*L* 38760	20 7 49	− 1 14	1913.538	83.28	64.74	....	3	*A* and *B*
....	....	....	......	1913.557	66.32	25.28	9.6 — 10.7	2	*B* and *C*
10025	153 *Cygni*	20 9 11	+51 6	1913.456	8.38	83.24	6.2 — 12.6	3	*A* and *C*
....	....	....	......	1913.541	80.55	74.29	— 12.0	2	*A* and *D*
10257	β 433	20 23 36	+55 55	1913.552	210.60	7.63	....	3	*A* and *B*
....	....	....	......	1913.552	244.55	27.64	....	3	*A* and *C*
10295	Ho 133	20 26 10	−13 57	1913.709	253.37	139.84	— 12.0	3	*AB* and *C*
10301	44 *Cygni*	20 26 26	+36 32	1913.441	165.46	63.05	— 12.5	4	*A* and *C*
....	*Groom.* 3226	20 29 59	+47 17	1913.549	17.27	117.70	6.5 — 9.0	4	....
10356	OΣ App (208)	20 30 54	+46 26	1913.552	241.21	78.37	—	3	....
10395	β 288	20 33 31	+15 25	1913.672	279.32	43.85	— 11.9	3	*A* and *C*
10453	α *Cygni*	20 37 20	+44 51	1913.549	105.54	75.47	....	4	....
10922	OΣ 437	21 15 46	+31 57	1913.546	140.39	86.13	— 11.3	3	*A* and *C*
10926	Σ 2789	21 16 7	+52 28	1913.479	171.53	126.60	— 12.0	3	*A* and *C*
10943	*S* 788	21 17 31	− 7 6	1913.541	88.85	45.82	....	4	....
11087	*H* 5284	21 30 52	−16 50	1913.665	268.87	50.22	....	3	....
11227	μ *Cephei*	21 39 50	+59 14	1913.564	260.84	19.64	....	3	*A* and *B*
....	....	....	......	1913.564	298.88	41.30	....	3	*A* and *C*
11361	OΣ App (226)	21 50 29	+67 32	1913.691	245.35	76.22	....	3	*A* and *B*
....	....	....	......	1913.679	149.12	85.14	....	3	*AB* and *C*
11434	29 *Aquarii*	21 55 52	−17 33	1913.710	291.09	143.01	— 12.2	3	*A* and *C*
11533	*H* 1735	22 4 21	+44 15	1913.659	109.60	26.87	....	3	*A* and *B*
....	....	....	......	1913.663	165.00	22.60	....	2	*B* and *C*
11646	30 *Pegasi*	22 14 25	+ 5 11	1913.659	224.30	12.19	....	3	*A* and *C*
11759	β 844	22 23 32	+ 5 2	1913.635	34.49	98.39	....	3	*A* and *B*
....	60 *Aquarii*	22 27 52	− 2 12	1912.894	297.82	95.68	6.2 — 10.6	3	*A* and *B*
....	....	....	......	1912.894	274.13	123.70	....	3	*A* and *C*
11888	β 277	22 34 14	+40 45	1913.552	116.40	25.58	— 12.5	3	*AB* and *C*
....	....	....	......	1913.549	47.27	74.67	— 8.5	4	*AB* and *BD* 40° (4874)
11914	Σ 2935	22 36 46	− 8 56	1913.703	357.57	70.05	7.0 — 11.2	5	*A* and *C*
....	....	....	......	1913.578	277.43	77.21	— 12.7	1	*A* and *D*
....	*BD* 79° (759)	22 57 2	+79 42	1913.482	11.21	49.79	7.5 — 10.5	3	....
12316	β 278	23 15 20	+61 33	1913.603	175.10	12.57	6.0 —	3	*A* and *B*
....	....	....	......	1913.597	259.18	58.35	— 11.5	3	*A* and *C*
....	....	....	......	1913.597	184.54	74.34	— 11.5	3	*A* and *D*
12392	Σ 3017	23 22 54	+73 37	1913.597	141.29	89.02	7.1 — 13.3	3	*A* and *C*
12413	Σ 3021	23 25 21	+15 33	1913.595	23.78	117.95	7.7 — 10.1	3	*A* and *C*
....	*H* 1899	23 34 19	+54 33	1913.730	254.80	16.16	....	3	....
12511	104 *Aquarii*	23 35 32	−18 29	1913.468	5.63	122.19	5.0 — 8.5	3	*A* and *B*
....	....	....	......	1913.468	76.04	90.16	— 12.5	3	*B* and *C*
12569	β 1152	23 42 18	+63 9	1913.628	135.86	74.43	....	3	*A* and *BC*
12621	Ho 205	23 47 58	+38 37	1913.730	249.68	92.51	6.5 — 11.1	3	*A* and *C*
....	....	....	......	1913.730	211.34	102.30	6.5 — 8.8	3	*A* and *D*

EPHEMERIS OF WOLF'S COMET FOR THE PERIOD JULY 1.0 TO DEC. 31.0, 1918,

By M. KAMENSKY.

My system of elements K_8', published in *A. J.* 729, forms the basis of the preliminary calculations for the present ephemeris. It represents pretty well the observed places of the comet through its five returns to the *Sun* during 1884–1912.

With the help of this system of elements K_8', I have calculated the exact values of the perturbations in the motion of Wolf's comet during the period Feb. 11.0, 1912 to Jan. 10.0, 1918; the first order perturbations due to *Jupiter* and *Saturn* had already been taken into consideration.

	δM	$\delta\varphi$	$\delta\Omega$	$\delta\pi$	δi	δn
	′ ″	′ ″	′ ″	′ ″	′ ″	″
Earth + Moon	−0 5.92	+0 0.04	−0 0.35	+0 2.39	0 0.00	+0.00609
Mars	+0 3.50	−0 0.19	−0 0.12	−0 0.14	+0 0.02	+0.00207
Jupiter	−0 48.36	+3 59.80	−3 5.85	+1 54.28	+1 49.07	+0.98789
Saturn	+0 27.86	−0 30.02	−0 1.66	−0 22.01	−0 11.41	−0.04742
Sum	−0 22.92	+3 29.63	−3 7.98	+1 34.52	+1 37.68	+0.94863

Adding these perturbations to the system K_8', I get the following system K_9', from which the ephemeris has been calculated.

January 10.0, 1918, B. M. T.

$$K_9' \quad \begin{array}{l} M = 311^\circ\ \ 1'\ 57''.83 \\ \varphi = \ \ 33\ \ 58\ \ 31.85 \\ \left.\begin{array}{l} \Omega = 206\ \ 34\ \ 45.34 \\ \pi = \ \ 19\ \ 29\ \ 31.92 \\ i = \ \ 25\ \ 17\ \ 34.74 \end{array}\right\} 1910.0 \\ \left.\begin{array}{l} \Omega = 206\ \ 41\ \ 31.71 \\ \pi = \ \ 19\ \ 36\ \ 13.54 \\ i = \ \ 25\ \ 17\ \ 31.56 \end{array}\right\} 1918.0 \\ n = 522''.42893 \end{array}$$

The rectangular heliocentric coördinates are given by:

$$\begin{aligned} x &= r[9.991851] \sin (107^\circ\ 21'\ 25''.9 + f) \\ y &= r[9.999980] \sin (\ \ 17\ \ 14\ \ 57\ \ .7 + f) \\ z &= r[9.283646] \sin (104\ \ 25\ \ 56\ \ .9 + f) \end{aligned}$$

Perihelion passage occurs Dec. 13.4281, 1918, B. M. T.

As may be seen in the following ephemeris, the position of Wolf's comet this year will be extremely favorable for observation, — especially in the northern hemisphere. Opposition to the *Sun* will be Aug. 7.65, 1918, and least distance from the *Earth* Sept. 19.67, 1918, when $\Delta = 1.0494$.

The matter of the future brightness of Wolf's comet is more difficult of decision, as internal changes in comets render the applicability of the expressions

$$T = T_0 \frac{r_0^2\,\Delta_0^2}{r^2\,\Delta^2} \qquad m = m_0 + 5 \log \left(\frac{r\,\Delta}{r_0\,\Delta_0}\right)$$

or similar formulas, uncertain. Nevertheless, it can be said with some assurance that during the last two revolutions (1899 to 1912) there occurred no sensible deviations from theory in the brightness of the comet. Indeed, assuming that the comet was of the 12th magnitude, as observed at Lick Observatory, Jan. 9, 1899, when $\log r_0 = 0.377$, $\log \Delta_0 = 0.190$, we find that for February 15, 1912, when $\log r = 0.201$, $\log \Delta = 0.371$, the comet was again of the 12th magnitude, which was exactly confirmed by an observation at Nice on that day.

As a basis for the following table of magnitudes for 1918, the following observations in 1912 were taken:

Jan. 16, 1912, Algiers, Eq. Coudé (0.32m)
$\log r = 0.213$, $\log \Delta = 0.351$, $m = 12.0$

Feb. 15, 1912, Nice, Eq. Coudé (0.40m)
$\log r = 0.201$, $\log \Delta = 0.371$, $m = 12$–12.5

Calculating from the first of these observations the brightness at the time of the second, by the above formula, we get $12^{M}.0$. Comparing this with the observation at Nice it is quite allowable to assume that for Feb. 15, 1912 the comet had a brightness

$$m_0 = 12^{M}.1$$

which value is the basis of the following table.

		M		M
1918	June 27	m = 11.8	Oct. 1	m = 10.5
	July 13	11.5	Oct. 17	10.5
	July 29	11.2	Nov. 2	10.5
	Aug. 14	10.9	Nov. 18	10.6
	Aug. 30	10.7	Dec. 4	10.8
	Sept. 15	10.5	Dec. 20	10.9

As the ephemeris is calculated with the constant system of elements K_9', and the further perturbations are not taken into consideration, so there may be expected some divergences, not very considerable, of the ephemeris from the observations. This is all the more possible, since the calculations were made with the help of 5-place tables, which give an accuracy of only about $0^s.3$, or $5''$. But the very hard conditions under which, at the present time, the work of the learned in Russia is carried on, have not given me the opportunity to prepare for publication at the proper time the more exact ephemeris. I hope, nevertheless, that my precedent researches on Wolf's comet will be published, — those which are already in press, and those which are finished and prepared for printing. These will give a quite sufficient theory of the motion of Wolf's comet during the whole period 1884–1919.

Ephemeris for 0h Berlin Mean Time

1918	α_{true}	Diff.	δ_{true}	Diff.	Log r	Log Δ	Aber. Time
	h m s	m s	° ′ ″	′ ″			m s
July 1	20 38 16.8	−0 32.1	+22 59 32	+24 26	0.3497	0.1729	12 22
3	20 37 44.7	−0 37.9	+23 23 58	+23 27	0.3473	0.1664	12 11
5	20 37 6.8	−0 44.1	+23 47 25	+22 24	0.3450	0.1600	12 0
7	20 36 22.7	−0 49.7	+24 9 49	+21 17	0.3426	0.1536	11 50
9	20 35 33.0	−0 55.2	+24 31 6	+20 4	0.3403	0.1473	11 39
11	20 34 37.8	−1 0.5	+24 51 10	+18 45	0.3379	0.1411	11 30
13	20 33 37.3	−1 5.6	+25 9 55	+17 22	0.3355	0.1350	11 20
15	20 32 31.7	−1 10.3	+25 27 17	+15 54	0.3331	0.1290	11 11
17	20 31 21.4	−1 14.8	+25 43 11	+14 22	0.3308	0.1231	11 2
19	20 30 6.6	−1 18.9	+25 57 33	+12 45	0.3284	0.1173	10 54
21	20 28 47.7	−1 22.7	+26 10 18	+11 5	0.3260	0.1117	10 45
23	20 27 25.0	−1 26.0	+26 21 23	+ 9 19	0.3236	0.1061	10 37
25	20 25 59.0	−1 29.0	+26 30 42	+ 7 29	0.3212	0.1007	10 29
27	20 24 30.0	−1 31.4	+26 38 11	+ 5 34	0.3187	0.0954	10 22
29	20 22 58.6	−1 33.3	+26 43 45	+ 3 37	0.3163	0.0902	10 14
31	20 21 25.3	−1 34.6	+26 47 22	+ 1 34	0.3139	0.0852	10 7
Aug. 2	20 19 50.7	−1 35.4	+26 48 56	− 0 34	0.3115	0.0804	10 0
4	20 18 15.3	−1 35.3	+26 48 22	− 2 42	0.3091	0.0757	9 54
6	20 16 40.0	−1 34.6	+26 45 40	− 4 49	0.3067	0.0712	9 47
8	20 15 5.4	−1 33.1	+26 40 51	− 6 59	0.3043	0.0668	9 42
10	20 13 32.3	−1 31.0	+26 33 52	− 9 13	0.3018	0.0627	9 36
12	20 12 1.3	−1 28.3	+26 24 39	−11 23	0.2994	0.0587	9 31
14	20 10 33.0	−1 24.8	+26 13 16	−13 29	0.2970	0.0549	9 26
16	20 9 8.2	−1 20.6	+25 59 47	−15 37	0.2946	0.0513	9 22
18	20 7 47.6	−1 15.7	+25 44 10	−17 46	0.2922	0.0479	9 17
20	20 6 31.9	−1 10.3	+25 26 24	−19 48	0.2898	0.0447	9 13
22	20 5 21.6	−1 4.3	+25 6 36	−21 46	0.2874	0.0417	9 9
24	20 4 17.3	−0 57.7	+24 44 50	−23 43	0.2850	0.0388	9 6
26	20 3 19.6	−0 50.6	+24 21 7	−25 40	0.2826	0.0362	9 2
28	20 2 29.0	−0 43.1	+23 55 27	−27 29	0.2802	0.0338	8 59
30	20 1 45.9	−0 35.2	+23 27 58	−29 12	0.2779	0.0316	8 56
Sept. 1	20 1 10.7	−0 26.7	+22 58 46	−30 51	0.2755	0.0296	8 54
3	20 0 44.0	−0 17.7	+22 27 55	−32 26	0.2732	0.0278	8 51
5	20 0 26.3	−0 8.2	+21 55 29	−33 53	0.2708	0.0263	8 50
7	20 0 18.1	+0 1.7	+21 21 36	−35 12	0.2685	0.0249	8 48
9	20 0 19.8	+0 11.7	+20 46 24	−36 25	0.2662	0.0237	8 47
11	20 0 31.5	+0 21.9	+20 9 59	−37 33	0.2639	0.0228	8 45
13	20 0 53.4	+0 32.2	+19 32 26	−38 31	0.2616	0.0220	8 45
15	20 1 25.6		+18 53 55		0.2594	0.0215	8 44

EPHEMERIS FOR 0h BERLIN MEAN TIME *(Continued.)*

1918	α_{true}	Diff.	δ_{true}	Diff.	Log r	Log Δ	Aber. Time
	h m s	m s	° ′ ″	′ ″			m s
Sept. 15	20 1 25.6		−18 53 55		0.2594	0.0215	8 44
17	20 2 8.1	+0 42.5	+18 14 32	−39 23	0.2571	0.0211	8 44
19	20 3 1.0	+0 52.9	+17 34 23	−40 9	0.2549	0.0210	8 44
21	20 4 4.4	+1 3.4	+16 53 34	−40 49	0.2527	0.0210	8 44
23	20 5 18.3	+1 13.9	+16 12 12	−41 22	0.2505	0.0212	8 44
25	20 6 42.6	+1 24.3	+15 30 23	−41 49	0.2484	0.0216	8 44
27	20 8 17.4	+1 34.8	+14 48 14	−42 9	0.2463	0.0222	8 45
29	20 10 2.7	+1 45.3	+14 5 50	−42 24	0.2442	0.0230	8 46
Oct. 1	20 11 58.3	+1 55.6	+13 23 18	−42 32	0.2421	0.0239	8 47
3	20 14 4.2	+2 5.9	+12 40 44	−42 34	0.2400	0.0250	8 48
5	20 16 20.1	+2 15.9	+11 58 15	−42 29	0.2380	0.0263	8 50
7	20 18 46.1	+2 26.0	+11 15 58	−42 17	0.2361	0.0278	8 51
9	20 21 21.7	+2 35.6	+10 33 56	−42 2	0.2341	0.0294	8 53
11	20 24 6.6	+2 44.9	+ 9 52 15	−41 41	0.2322	0.0312	8 55
13	20 27 0.9	+2 54.3	+ 9 11 1	−41 14	0.2303	0.0331	8 58
15	20 30 4.7	+3 3.8	+ 8 30 20	−40 41	0.2285	0.0352	9 0
17	20 33 17.6	+3 12.9	+ 7 50 15	−40 5	0.2267	0.0374	9 3
19	20 36 39.0	+3 21.4	+ 7 10 50	−39 25	0.2250	0.0397	9 6
21	20 40 8.8	+3 29.8	+ 6 32 10	−38 40	0.2233	0.0423	9 9
23	20 43 46.8	+3 38.0	+ 5 54 20	−37 50	0.2216	0.0449	9 12
25	20 47 32.6	+3 45.8	+ 5 17 21	−36 59	0.2200	0.0477	9 16
27	20 51 26.1	+3 53.5	+ 4 41 16	−36 5	0.2185	0.0505	9 20
29	20 55 26.9	+4 0.8	+ 4 6 10	−35 6	0.2170	0.0535	9 24
31	20 59 34.7	+4 7.8	+ 3 32 6	−34 4	0.2155	0.0567	9 28
Nov. 2	21 3 49.4	+4 14.7	+ 2 59 5	−33 1	0.2141	9.0599	9 32
4	21 8 10.9	+4 21.5	+ 2 27 9	−31 56	0.2128	0.0632	9 36
6	21 12 38.7	+4 27.8	+ 1 56 22	−30 47	0.2115	0.0667	9 41
8	21 17 12.4	+4 33.7	+ 1 26 47	−29 35	0.2103	0.0702	9 46
10	21 21 51.9	+4 39.5	+ 0 58 25	−28 22	0.2091	0.0739	9 51
12	21 26 36.9	+4 45.0	+ 0 31 17	−27 8	0.2080	0.0776	9 56
14	21 31 27.0	+4 50.1	+ 0 5 24	−25 53	0.2069	0.0814	10 1
16	21 36 22.0	+4 55.0	− 0 19 11	−24 35	0.2059	0.0853	10 6
18	21 41 21.4	+4 59.4	− 0 42 30	−23 19	0.2050	0.0893	10 12
20	21 46 25.0	+5 3.6	− 1 4 34	−22 4	0.2041	0.0934	10 18
22	21 51 32.5	+5 7.5	− 1 25 20	−20 46	0.2034	0.0975	10 24
24	21 56 43.6	+5 11.1	− 1 44 47	−19 27	0.2026	0.1017	10 30
26	22 1 58.2	+5 14.6	− 2 2 56	−18 9	0.2020	0.1060	10 36
28	22 7 15.9	+5 17.7	− 2 19 47	−16 51	0.2014	0.1103	10 42
30	22 12 36.4	+5 20.5	− 2 35 21	−15 34	0.2009	0.1147	10 49
Dec. 2	22 17 59.6	+5 23.2	− 2 49 37	−14 16	0.2004	0.1192	10 56
4	22 23 25.4	+5 25.8	− 3 2 36	−12 59	0.2000	0.1237	11 3
6	22 28 53.6	+5 28.2	− 3 14 21	−11 45	0.1997	0.1282	11 10
8	22 34 23.8	+5 30.2	− 3 24 52	−10 31	0.1995	0.1328	11 17
10	22 39 55.8	+5 32.0	− 3 34 9	− 9 17	0.1994	0.1375	11 24
12	22 45 29.3	+5 33.5	− 3 42 15	− 8 6	0.1993	0.1421	11 32
14	22 51 3.8	+5 34.5	− 3 49 11	− 6 56	0.1992	0.1468	11 39
16	22 56 39.4	+5 35.6	− 3 54 57	− 5 46	0.1993	0.1516	11 47
18	23 2 15.9	+5 36.5	− 3 59 35	− 4 38	0.1994	0.1563	11 54

EPHEMERIS FOR 0h BERLIN MEAN TIME (*Continued.*)

1918	α_{true}	Diff.	δ_{true}	Diff.	Log r	Log Δ	Aber. Time
	h m s	m s	° ′ ″	′ ″			m s
Dec. 18	23 2 15.9	+5 37.2	−3 59 35	−3 33	0.1994	0.1563	11 54
20	23 7 53.1	+5 37.9	−4 3 8	−2 30	0.1996	0.1611	12 2
22	23 13 31.0	+5 38.3	−4 5 38	−1 29	0.1999	0.1659	12 10
24	23 19 9.3	+5 38.3	−4 7 7	−0 30	0.2003	0.1708	12 18
26	23 24 47.6	+5 38.0	−4 7 37	+0 28	0.2007	0.1756	12 26
28	23 30 25.6	+5 37.6	−4 7 9	+1 22	0.2012	0.1805	12 35
30	23 36 3.2	+5 36.8	−4 5 47	+2 15	0.2017	0.1854	12 43
32	23 41 40.0		−4 3 32		0.2023	0.1903	12 52

Naval Observatory, Vladivostok, May, 1918.

THE SOLAR ECLIPSE, JUNE 8, 1918.

[Communicated by J. G. PORTER.]

The eclipse was observed at Cincinnati by J. G. PORTER with the 4-inch equatorial, by E. I. YOWELL with the 16-inch equatorial reduced to 5 inches, and by ELLIOTT SMITH with the $2\frac{1}{2}$-inch finder of the 11-inch equatorial. Owing to the low altitude of the *Sun*, the times of ending are somewhat uncertain.

	Beginning Cin. M. T.	Ending Cin. M. T.
J. G. P.	$4^h\ 51^m\ 33^s$	$6^h\ 46^m\ 22^s$
E. I. Y.	51 32	46 25
E. S.	51 42	46 29

NOVA AQUILÆ, NO. 3.

Nova Aquilæ, No. 3 was discovered independently by a number of people on the night of June 8, 1918. On June 8 it was about $+0^M.5$ and on June 9, $-1^M.4$ according to BARNARD. PARKHURST found its spectrum of the first type with dark lines on June 8.

The Harvard College Observatory plates show the star to have been about $10^M.5$ with a variation of at least a magnitude. On June 3, 1918 it was of normal magnitude. June 4, 5 and 6 were cloudy but on June 7 it was sixth magnitude. The *Nova* is fading regularly. On June 12 it was $+1^M.0$ and on June 22 was $2^M.5$. Its light curve closely resembles that of *Nova Persei*, No. 2 according to PROF. E. C. PICKERING.

PARKHURST found from a series of plates that the change from Type *A* to that of the typical *Nova* occurred during the daytime of Monday, June 10.

The position of the *Nova* is R. A. $18^h\ 43^m.8$, Dec. $+0°\ 29'$ (1900).

NEW ASTRONOMICAL WORK.

Catalogue Photographique du Ciel. Observatoire de Toulouse. Tome VI. Zone +4° a +60°. Deuxieme fascicule de $6^h\ 8^m$ a 24^h. Paris 1916.

On the Distribution of the Mean Motions of the Asteroids, by KIYOTSUGU HIRAYAMA. *Annales de l'Observatoire Astronomique de Tokyo.* Appendice 2, 1917.

Absorption and Radiation of the Solar Atmosphere, by KIYOTSUGU HIRAYAMA. *Annales de l'Observatoire Astronomique de Tokyo.* Appendice 3, 1918.

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NOVA AQUILÆ. NO. 3.
NEW ASTRONOMICAL WORK.

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NEW DOUBLE STARS,

MEASURES OF DOUBLE STARS,

By E. D. Roe, Jr.

FIRST LIST.

The following pairs of stars were found and measured with the 24-in. Brashear Refractor of the Sproul Observatory at Swarthmore, Pa., or with the 6½-in. Clark Refractor of my observatory. During the month of August I was permitted, through the courtesy of the Director, Dr. John A. Miller, to use the 24-in. refractor. I am under especial obligation to him for this privilege. I am also under obligation to Messrs. Pitman and Matos, of the staff, for generous aid. My thanks are due to Prof. Eric Doolittle for comparing the stars found with his card catalogue of new double stars recently found. I am also indebted to Mrs. Roe for going over the calculations. The positions, corrected for precession, are given for 1915 and 1880. In parentheses are indicated the magnitudes the telescope with which the discovery or measurement was made, and the date of discovery. The optical and mechanical qualities of the 24-in. are too well known to require extended discussion. The objective and mounting satisfy every requirement. During the month of August the weather was not especially favorable and considerable unfavorable weather prevailed.

ρ 95, *B.D.* −0° 3147
$16^h 32^m 49^s$, −1° 8′ (9.5, 10.8, 12)
(6½-in.; 22 June, 1916)

		°	″
AB	1916.488	234.9	7.77
	.493	233.7	8.07
	.512	232.4	7.90
	1916.498	233.7	7.91
AC	1916.493	347.7	55.20

ρ 96
$17^h 36^m 7^s$, 12° 56′ (9.8, 10.6)
$1^m 38^s.1$ following and 8′ north of
BD 12° 3267 (6½-in.; 7 July, 1916)

1916.548	63.5	6.13
.551	64.8	6.64
.559	63.4	6.36
1916.553	63.9	6.38

ρ 97, *B.D.* 10° 3398
$18^h 4^m 32^s$, 10° 13′ (10.3, 10.4)
(24-in.; 6 August, 1916)

1916.630	148.2	1.05
.633	146.9	1.40
.636	146.5	1.23
1916.633	147.2	1.23

ρ 98, *B.D.* 10° 3401
$18^h 4^m 46^s$, 10° 14′ (10.2, 10.3, 13, 13.5)
(6½-in.; 22 July, 1916)

		°	″	
AB	1916.553	271.0	4.60	
	.578	271.1	3.82	
	.586	270.8	4.57	
	1916.572	271.0	4.33	
AB	1916.600	260°	20″	estimated
CD	1916.600	180°	25″	estimated

C and *D* were first detected with the 24-in., afterwards with the 6½-in.

AB	1916.608	270.3	4.72	24-in.
AC	1916.617	260.6	29.42	24-in.
CD	1916.630	176.6	32.08	24-in.

Other more distant faint companions.

ρ 99, *B.D.* 8° 3667
$18^h 18^m 48^s$, 8° 32′ (10.1, 10.1, 11.5)
(6½-in.; 22 July, 1916)

		°	″	
AB	1916.578	219.2	5.92	
	.586	220.2	4.88	
	1916.582	219.7	5.40	
	1916.638	223.7	6.14	24-in.
AC	1916.578	230.4	27.18	
	.586	230.2	26.25	
	1916.582	230.3	26.72	
	1916.638	230.5	27.13	24-in.

ρ 100, *B.D.* 8° 3670
$18^h 19^m 39^s$, 8° 26′ (9.0, 10.1, 11)
(24-in.; 20 August, 1916)

AB	1916.638	208.0	24.25
	.644	206.4	23.94
	.649	207.1	24.46
	1916.644	207.2	24.22
BC	1916.638	344.1	4.40
	.644	345.1	5.01
	.649	344.4	3.88
	1916.644	344.5	4.43

ρ 101, *B.D.* 19° 4342
$20^h 11^m 51^s$, 19° 42′ (8.6, 9.8, 11.3, 11.5, 12) (6½-in.; 9 Sept., 1916)

AB	1916.693	51.7	12.18
	.701	51.7	13.67
	1916.697	51.7	12.93

AC	1916.693	189.4	45.07
	.701	190.1	44.63
	1916.697	189.8	44.85

AD	1916.701	270.0	13.97	
AE	1916.709	60.	45.	est.

ρ 102, *B.D.* 12° 4568
$21^h\ 7^m\ 31^s$, 12° 30′ (9.7, 9.8)
(6½-in.; 12 September, 1916)

1916.701	116.5	5.89
.704	116.6	5.39
.712	116.2	5.03
1916.706	116.4	5.44

10802 H 277 is 23′ south and 1^s preceding.

ρ 103, *B.D.* 8° 5063
$23^h\ 22^m\ 58^s$, 8° 58′ (10.2, 10.7)
(24-in.; 19 August, 1916)

1916.636	127.3	1.48
.638	130.0	1.58
.649	127.7	1.69
1916.641	128.3	1.58

ρ 104, *B.D.* 14° 5052
$23^h\ 41^m\ 53^s$, 14° 26′ (9.5, 11.6)
(24-in.; 22 August, 1916)

1916.644	150.3	1.64
.660	151.4	1.74
1916.652	150.9	1.69

ρ 105, *B.D.* 29° 250
$1^h\ 24^m\ 52^s$, 29° 58′ (9.9, 9.9)
(6½-in.; 25 Sept., 1916)

1916.737 356°.2 5″.14

The positions of the preceding stars for 1880:

ρ 95	$16^h\ 31^m\ 1^s$, −1° 3′
ρ 96	$17^h\ 34^m\ 30^s$, 12° 57′
ρ 97	$18^h\ 2^m\ 53^s$, 10° 13′
ρ 98	$18^h\ 3^m\ 7^s$, 10° 13′
ρ 99	$18^h\ 17^m\ 7^s$, 8° 31′
ρ 100	$18^h\ 17^m\ 58^s$, 8° 25′
ρ 101	$20^h\ 10^m\ 18^s$, 19° 36′
ρ 102	$21^h\ 5^m\ 50^s$, 12° 21′
ρ 103	$23^h\ 21^m\ 14^s$, 8° 46′
ρ 104	$23^h\ 40^m\ 7^s$, 14° 14′
ρ 105	$1^h\ 22^m\ 56^s$, 29° 47′

With the exception of ρ 2, ζ *Herculis* and H 277, the following pairs were measured before being identified as old.

73 Σ 9 (6½-in.)

	°	″
1916.699	165.6	19.78

ρ 2, *B.D.* 46° 2073 (6½-in.)

1916.699	82.6	4.47
.704	84.0	3.67
.712	83.2	3.99
1916.705	83.3	4.04

1915.497 83°.3 4″.45 ρ 2*n* 12-in.

7717 ζ *Herculis* (6½-in.)

	°	″
1916.536	105.6	1.52
.539	104.6	1.83
.693	106.9	1.31
1916.589	105.7	1.55

1915.652 109°.3 1″.51 ρ 1*n* 40-in.

7986 Σ 2157 (6½-in.)

1916.515	206.5	2.84
.518	206.3	3.27
.528	204.6	3.34
1916.520	205.8 .	3.15

10802 H 277 (6½-in.) (9.8, 10.8)

1916.737 317.8 13.71

No measure in the *G. C.*

11943 β 711 (24-in.) (9.4, 10.5)

1916.636	27.3	1.22	
.638	27.8	1.35	
.644	29.5	1.38	
1916.639	28.2	1.32	
1878.59	79.9	0.72	1*n* β
1898.74	47.6	0.99	3*n* A
1902.27	44.0	0.95	6*n* Doo

SECOND LIST.

ρ 106, *B.D.* 18° 128
$0^h\ 52^m\ 37^s$, 19° 16′ (1915)
$0^h\ 50^m\ 46^s$, 19° 05′ (1880)
(10.2, 10.4) (6½-in. 28 Oct. 1916)

	°	″
1916.841	97.1	1.57
.865	98.1	.54
.893	98.5	.68
1916.866	97.9	1.60

One of the most difficult pairs I ever handled with this aperture. It was later found that the difficulty was due to atmospheric conditions, since under favorable circumstances it was easy with all powers. The distance may be 2″.0 or more. It should be measured with a large aperture to get sufficient light to set the threads accurately. On being referred to Prof. Eric Doolittle, he pronounced it "new."

ρ 105, *B.D.* 29° 250

	°	″
1916.737	356.2	5.14
.751	.3	4.70
.754	.1	5.18
1916.747	356.2	5.01

1070 γ_2 *Andromedæ*

1916.896	108.1	0.42
.939	109.5	0.68
.942	109.4	0.69
1916.926	109.0	0.60

3145 Σ 2218

1916.770	340.0	2.08	
.781	340.4	1.93	
.784	339.9	2.15	
1916.778	340.1	2.05	
1832.72	356.7	2.50	4*n* Σ
1902.42	344.7	2.08	2*n* Hl

3919 OΣ 170

	°	″
1916.195	100.5	1.38
.247	102.9	1.33
1916.221	101.7	1.36
1844.79	133.0	0.96 2*n* OΣ
1898.08	110.0	1.47 4*n* Hl

5388 γ *Leonis*

1916.419	118.1	3.80
.493	117.3	3.97
1916.456	117.7	3.88

8118 Σ 2194

1916.784	80.0	1.54
.813	85.1	1.43
1916.799	82.6	1.49
1830.94	116.4	1.67 3*n* Σ
1879.47	98.5	1.67 3*n* Hl
1898.33	88.9	1.56 3*n* Doo

10802 H 277

1916.737	317.8	13.71
.751	318.4	12.25
.754	318.1	12.32
1916.747	318.1	12.76

ρ 23

	°	″
1916.751	83.8	10.71
.765	.9	11.15
1916.758	83.9	10.93

ρ 24

1916.751	170.2	10.88
.765	.1	11.31
1916.758	170.2	11.10

ρ 24 A – ρ 23 A

1916.751	265.9	79.11
.765	.9	81.15
.768	.9	79.78
1916.761	265.9	80.01

A.G. Leip. 8617, *B.D.* 13° 4757
(9.6, 9.9)

1916.790	220.5	3.23
.794	.1	.19
.813	.1	.21
1916.799	220.2	3.21
1903.77	221.8	2.89 2*n* Cl

11590 Σ 2878

	°	″
1916.790	124.4	1.15
1830.31	130.8	1.36 4*n* Σ
1891.72	126.0	1.36 3*n* β
1902.66	126.4	1.50 2*n* Hu

R J 298 (10.3, 10.6)

23^h 26^m 12^s, 8° 16′ (1915)
23^h 24^m 26^s, 8° 4′ (1880)

2^m 27^s.2 following and 6′ north of *B.D.* 7° 5033.

(Measured with the 24-in. refractor of the Sproul Observatory.)

1916.649	117.8	5.00
.652	121.3	4.79
1916.651	119.6	4.89

All the stars in this list, except R.J. 298, were found or measured with the 6½-in. Clark refractor of my observatory.

CORRECTIONS AND ADDITIONS

ρ 23. Position correct. "Following" should be "preceding."

ρ 24. Position practically correct. 21^h 17^m 55^s, 36° 55′ (1910) 0′.1 north instead of 1′ north of ρ 23. To the distance ρ 24 A — ρ 23 A add 10″.02 since ρ 24 A — ρ 23 B was probably measured, so distance 24A – 23A 1909.918 = 80″.85 instead of 70″.83.

ρ 31. P. A. 176. Rough place –3° 4′ should be –3° 45′, but this pair has been replaced. *A.N.* 4830.

ρ 33. +11° 2037 should be +7° (2037).

ρ 38. Found 1910, June 4

ρ 46 = Espin 261.

ρ 51 = β 51.

ρ 53. P. A. 179. The description is under ρ 59. Correct in *A. N.* 4510.

ρ 55. Position correct. –0° 4363 should be –0° 4353.

ρ 58. The declination is 46° 17′.

ρ 59. P. A. 179. Description belongs to ρ 53.

ρ 78 = β 442 Aa. The measures of angle were 153°.6, 153°.0, 154°.8 making the average 153°.8 for 1913.675.

ρ 79 = *A.G. Leip.* (*A.G. Leip.*, p. 211).

ρ 81. The declination is 35° 44′.

ρ 82. Found at the Yerkes Observatory with the 40-in. Following is the exact position.

B.D. 49° 6 0^h 4^m 21^s, 49° 27′ (1915)
0^h 2^m 34^s, 49° 15′ (1880)

(24-in.) (10.2, 10.3, 13)

		°	″
AB	1916.633	283.3	0.65
	.660	283.3	0.64
	1916.647	283.3	0.65

I now reverse the angle.

		°	″
	1915.645	101.5	0.78 ρ 2*n* 40-in.
AC	1916.660	248.7	21.28
	1915.657	246.0	22. est.

THIRD LIST.

The following pairs of stars having been examined by Prof. Eric Doolittle were found by him to be new. Through the courtesy of Dean Herbert A. Howe, Director of the Chamberlin Observatory of the University of Denver, the authorities of the University generously placed the equipment of the observatory at my disposal. During three hours each of six nights in August I worked on the discovery, measurement and location of new double stars. I am under especial obligation to the authorities and Dean Howe for this privilege. Some new pairs were found and measured together with others which were afterwards found to be known pairs. Some other pairs have also been found with the 6½-in. Clark refractor of my observatory. The exact position of all the new pairs, both those found with the 20-in. and the 6½-in., has been determined with the 6½-in. The positions are given for 1880 and 1917. In parentheses are indicated as is the case with my other lists the magnitudes, the telescope with which the discovery or measurement was made, and the date of discovery. Where two telescopes were used on the same pair it is indicated in the measurements.

ρ 107, *B.D.* +7° 2016

$8^h\ 35^m\ 1^s$, +7° 16′ (1880)
8 37 00, + 7 9 (1917)
(9.5, 10) (24 March, 1917; 6½-in.)

1917.227	257.7	2.57
.233	.7	.47
.244	.8	.11
1917.235	257.7	2.38

ρ 108, (9.9, 9.9)

$17^h\ 17^m\ 35^s$, +30° 17′ (1880)
17 19 0, +30 14 (1917)

$1^m\ 39^s.1$ following and 3′.5 south of *B.D.* +30° 2970 (4 July, 1917; 6½-in.)

1917.507	359.9	4.90
.510	359.8	5.27
.515	358.8	5.78
1917.511	359.5	5.32

ρ 109, *B.D.* +12° 3381

$18^h\ 0^m\ 2^s$, +12° 42′ (1880)
18 0 44 +12 42 (1917)
(9.9, 9.9) (18 August, 1917; 20-in.)

1917.630	128.2	1.82
.641	130.3	2.06
1917.636	129.3	1.94

ρ 110, *A.G. Leipzig* 6467

$18^h\ 5^m\ 24^s$, +12° 50′ (1880)
18 7 7, +12 50 (1917)
(9.5, 13) (22 August, 1917; 20-in.)

1917.641	136.3	2.87
.646	135.1	3.11
1917.649	135.7	2.99

This pair is *B.D.* +12° 3417 but the position was determined from the *A.G. Catalogue.*

ρ 111, *B.D.* +13° 3602

$18^h\ 13^m\ 29^s$, +13° 13′ (1880)
18 15 11, +13 44 (1917)
(9.8, 10.5) (24 August, 1917; 20-in.)

	°	″	
1917.646	68.7	3.63	20-in.
.726	.0	.64	6½-in.
1917.686	68.4	3.64	

Positions determined from *A.G. Leipzig* 6553 (= *B.D.* +13° 3606) by the following observation: 1917.726, *A.G. Leipzig* 6553 — *B.D.* +13° 3602 $\Delta\alpha = -39^s.3$, $\Delta\delta = +2'.7$.

ρ 112, *B.D.* +9° 3910

$18^h\ 47^m\ 41^s$, +9° 3′ (1880)
18 49 30, +9 6 (1917)
(9.5, 9.9, 9.4) (22 Sept., 1917; 6½-in.)

AB	1917.726	237.6	6.96
AC	1917.726	225.4	48.23

C is *B.D.* +9° 3912

ρ 113, *B.D.* +11° 3663

$18^h\ 49^m\ 38^s$, +11° 35′ (1880)
18 51 21, +11 37 (1917)
(10.2, 10.2, 10.4)
(29 August, 1917; 20-in.)

		°	″	
AB	1917.660	184.5	2.12	20-in.
AC	1917.660	306.6	21.81	20-in.
	.704	306.8	22.21	6½-in.
AC	1917.682	306.7	22.01	

ρ 114, *B.D.* −6° 5645

$20^h\ 53^m\ 46^s$, −6° 9′ (1880)
20 55 44, −6 0 (1917)
(9.8, 10.2, 10.5, 10.6)
(2 October, 1917; 6½-in.)

		°	″
AB	1917.745	304.8	5.59
	.778	306.7	5.86
	.789	305.8	6.13
	1917.771	305.8	5.86
AC	1917.745	227.2	42.52
AD	1917.745	140.8	89.81

A brighter and wider pair was observed in the same low power field as follows: ρ 114 ———— pair. $\Delta\alpha = +22^s.2$, $\Delta\delta = -7'.25$. Therefore the pair is *B.D.* −6° 5648 (9.6, 9.9).

1917.778	87.8	13.44
.789	87.4	12.28
1917.784	87.6	12.81

MEASURES AND OBSERVATIONS OF DOUBLE STARS.

The following stars were observed for one or another reason.*

1070 γ *Andromedæ*

		°	″
$A-BC$	1917.080	64.3	10.45

This measure was made with the 6½-in. at 3 P.M. with the sun shining brightly in a clear sky.

4122 *Castor*

	°	″
1917.312	218.4	6.03
.361	.3	5.59
1917.337	218.4	5.81

PETTIT (13) (*A.J.* 715, p. 174)

This pair is *B.D.* −14° 2751 as the following observations show. Using the finder field given me by PETTIT I measured:

8^m — P(13) $\Delta\alpha = -3^m\,30^s.0,$
$\Delta\delta = -3'.18$

9^m — P(13) $\Delta\alpha = +9^s.5,\ \Delta\delta = +9'.3$

From the *B.D.*, we find:

−14° 2772 — 2751 $\Delta\alpha = -3^m\,29^s.3,$
$\Delta\delta = -3'.2$

−15° 2703 — (−14° 2751)
$\Delta\alpha = +9^s.8,$
$\Delta\delta = +9'.5$

From the magnitudes it is probable that PETTIT'S (1), (10), (11), (16), (17), (certainly the last three) are *B.D.* stars.

5103 ω *Leonis*

	°	″	
1917.306	126.4	0.89	
Previous measures:			
1900.301	113.72	1.00	Doo 5
1903.244	116.85	0.80	Doo 3
1908.050	121.0	1.01	Doo 7

5765 ι *Leonis*

1917.306	42.6	2.09	
1900.274	55.05	2.37	Doo 3
1907.110	49.1	2.31	Doo 4

5388 γ *Leonis*

1917.361	117.3	3.88	(sunlight)
1910.120	116.6	3.94	Doo 3

6955 ζ *Bootis*

1917.449	140.1	0.71	(twilight)
.459	139.6	.74	(twilight)
.466	140.0	.76	(sunlight)
1917.458	139.9	0.74	
1909.45	144.6	0.66	Doo 3

6993 ε *Bootis*

1917.449	332.6	3.11	(twilight)
.459	331.6	3.13	(twilight)
.466	332.1	2.97	(sunlight)
1917.458	332.1	3.07	

7368 γ *Coronæ Borealis*

1917.459	113.8	0.71	
.471	115.5	.71	
.482	116.7	.75	
1917.471	115.3	0.72	
1900.509	116.34	0.74	Doo 5
1908.390	112.0	0.53	Doo 8

7717 ζ *Herculis*

	°	″	
1917.507	99.3	1.30	
.510	.9	.34	(daylight)
.515	.3	.62	
1917.522	99.5	1.42	
	°	″	
1915.652	109.3	1.51	40-in. (sunlight)
1916.589	105.7	1.55	3

ρ 97, *B.D.* +10° 3398

1917.630	....	1.47	20-in.
1916.633	147.2	1.23	24-in. 3

Discovered with the 24-in. of the Sproul Observatory.

ρ 98, *B.D.* +10° 3401 *AB*

1917.570	270.8	4.64	
.580	.8	.06	
.586	.0	.72	
.608	.6	.90	20-in.
1917.588	270.6	4.58	
1916.572	271.0	4.33	3
1916.608	270.3	4.72	24-in.

Discovered with the 6½-in. No apparent change.

9374 β *Cygni*

1916.799	54.3	35.80

9605 δ *Cygni*

1917.583	282.8	1.85	
.586	283.7	.73	
.589	282.6	.74	
1917.586	283.0	1.77	
1912.583	281.4	2.04	Fox 5

The following were found in searching for new pairs and measured before they were identified as known. Many others have also been found and identified before measuring was applied.

479 66 *Piscium* (6½-in.)

	°	″	
1917.792	304.5	0.57	
.847	303.9	0.62	
1917.819	304.2	0.60	
1910.784	307.4	0.46	Fox 3
1907.490	314.5	0.53	Doo 6
1903.950	321.2	0.50	V. B. 3†

2439 Σ 620 (6½-in.)

	°	″	
1917.063	234.8	4.01	
1831.120	226.3	3.59	Σ 4
1896.160	231.2	3.64	A 3

---

* Unless otherwise specified it is to be understood that the observations were made with the 6½-in.

† V. B. = Van Biesbroeck.

2805 *A.G.* 96 (6½-in.)

1917.222	229.7	3.99	
.227	230.2	3.36	
.233	232.4	4.17	
1917.227	230.8	3.84	
1903.100	234.1	4.69	M 3
1909.920	233.6	4.89	Doo 2
1912.289	233.03	5.30	Fox 3

7140 Σ 1988 (6½-in.)

1917.486	258.1	3.53	
1911.250	260.4	2.59	Doo 3
1830.050	266.3	2.91	Σ 3

8168 Σ 2222 (20-in.)

1917.665	59.5	2.08	
1830.420	58.6	2.08	Σ 3
1902.430	59.7	2.05	Hu 3

R. J. 753 *B.D.* 15° 3275

17h 42m 51s, 15° 49′ (1880)

(10.2, 10.4) (20-in.)

	°	″	
1917.665	272.4	1.92*	
1912.330	97.0	0.85	(9.3, 9.3) J 1
1916.340	275.1	1.04	(9.6, 10.7) Doo 3

R. J. 458 17h 50m 23s, 8° 33′ (1880)

(10, 12) (20-in.)

40s.1 following and 1′.8 south of *A.G. Leipzig* 8169.

1917.635	112.6	4.70	
.641	.4	.95	
1917.638	112.5	4.83	
1911.480	118.9	3.21	(9.3, 11) J 2
1916.380	118.0	3.66	(10.4, 11.7) Doo 3

B.D. +17° 3390 (9.5, 9.8)

17h 52m 22s, 17° 7′ (1880) (20-in.)

1917.665	197.9	2.73	
.704	198.4	2.52	(6½-in.)
1917.685	198.2	2.63	
1909.440	195.6	2.32	(9.4, 9.7) A 2

8377 Σ 2280 (6½-in.)

	°	″	
1917.507	181.8	14.57	
.510	.7	.14	
.548	.8	.01	
1917.522	181.8	14.24	
1831.720	182.9	13.85	Σ 6
1865.520	182.8	14.02	Δ 3
1905.760	182.4	14.00	β 3

8497 *A.G.* 221 (6½-in.)

1917.548	10.6	1.61	
.847	.6	.57	
1917.678	10.6	1.59	
1901.710	14.4	1.42	Hu 3
1903.730	11.3	1.29	V. B. 2

8516 *A.G.* 222 (20-in.)

1917.701	143.1	1.95	(6½-in.)
1900.240	148.8	1.88	P 2
1910.700	146.0	1.83	Doo 2
1910.427	143.7	1.85	Fox 3

8633 Hu 245 (20-in.) (9.5, 10.3)

1917.646	53.6	2.52	
1899.070	52.4	2.06	Hu 3
1909.540	50.5	2.07	(8.5, 10.2) Doo 3
1911.529	50.7	2.15	Fox 4
1903.620	54.2	2.00	V. B. 2

8703 H 1333 (6½-in.)

1917.844	226.2	2.32	
.847	227.5	.32	
.852	226.3	.29	
1917.848	226.7	2.31	
1828.+	229.0	2 ±	H
1875.980	227.0	2.68	Δ 3
1903.830	227.5	2.78	Howard 3
1904.610	224.5	2.88	M 3

8711 Σ 2360 (6½-in.)

1917.556	360.5	2.07	
.844	361.6	1.92	
.847	358.6	2.27	
.852	360.9	2.02	
1917.795	360.4	2.09	
1831.070	5.7	2.53	Σ 3
1886.560	1.0	2.49	Hl 3

8851 Hu 328 (6½-in.)

	°	″	
1917.556	188.7	3.55	
1901.790	189.0	4.70	Hu 3
1909.500	189.9	4.47	Doo 3

8885 Hu 258 (20-in.)

1917.660	216.4	2.45	
1900.600	216.1	2.53	Hu 3

9625 Espin 83 (6½-in.) (9.5, 9.6)

1917.591	208.4	7.41	

11m at 270° 64″.60

1901....	214.7	7.7	Es
1911.769	211.1	7.29	Fox 3

10063 β 442 Aa (6½-in.)†

1917.580	153.1	4.36	
.710	155.9	2.63	
1917.645	154.5	3.50	
1898.600	156.9	3.88	β 1
1899.750	155.7	4.01	Doo 4

10352 Σ 2699 (6½-in.)

1917.743	193.5	9.99	
1829.870	192.2	9.56	Σ 2
1904.610	195.1	9.51	β 2

10690 Σ 2746 (6½-in.)

1917.580	301.1	1.07	
1830.820	276.2	0.87	Σ 4
1884.700	295.7	1.01	Hl 3
1900.500	294.1	1.03	Doo 3
1902.880	297.6	1.05	Do 2

10801 H I 47 (6½-in.)

1917.743	315.6	3.56	
.854	316.4	.66	
.857	315.9	.89	
1917.818	316.0	3.70	
1802.660	336.8	...	H 1
1882.730	320.2	3.08	Hl 5
1908.707	316.2	3.34	Fox 2

11101 H 3078 (6½-in.)

1917.728	184.6	3.96	
.852	185.5	4.22	
1917.790	185.1	4.09	
1830.+	195.0	3 ±	H

Ru Observatory, 10 November, 1917.

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* I measured a 10.4 comes to R. J. 753 as follows:

1917.665	180.7	48.61	(20-in.
.701	178.9	47.39	(6½-in.)
1917.685	179.8	48.00	

† Published as ρ78 in *A.N.* 4762. It is *B.D.* +37° 3859.

SECOND ELEMENTS AND EPHEMERIS OF 1917 *W 15*,

By ERNEST CLARE BOWER and CHARLES CLAYTON WYLIE.

[Communicated by Rear Admiral THOS. B. HOWARD, U. S. Navy, Superintendent U. S. Naval Observatory.]

Additional observations made at the U. S. Naval Observatory, Washington, are available. The numbering is continued from *A. J.* **31**, 65.

	G. M. T. 1918	α (1918.0) ° ′ ″	δ (1918.0) ° ′ ″	Log $p_\alpha\rho$	Log $p_\delta\rho$	Observer	Instrument
(14)	Jan. 12.65162	38 12 56.6	+15 19 59.6	0.743	0.619	HALL	26-inch
(15)	Feb. 4.58523	42 14 47.1	18 19 45.5	0.714	0.570	BOWER	26-inch
(16)	12.54668	44 11 49.4	19 22 49.7	0.649	0.530	BOWER	26-inch
(17)	13.54152	44 27 25.0	19 30 42.5	0.638	0.525	BOWER	26-inch
(18)	Mar. 2.54916	49 25 0.4	21 42 30.9	0.760	0.547	BOWER	26-inch
(19)	5.58775	50 23 31.5	22 5 23.1	0.834	0.612	BOWER	26-inch
(20)	15.57234	53 45 39.3	+23 18 23.3	0.840	0.606	BOWER	26-inch

A second orbit based on (1), (2) and (3) as a normal first place, (12) and (13) as a normal middle place, and (20) as third place yields the residuals:

	I	II	III
$\Delta\alpha$	+1″.6	+0″.6	−0″.1
$\Delta\delta$	+0 .9	+0 .2	0 .0

Perturbations, investigation of star places and differential reduction to apparent place have been neglected.

SECOND ELEMENTS

Epoch = 1918 Jan. 6.5 G. M. T.

$M = 36^\circ\,49'\,43''.8$ $m_0 = 13.5$
$\mu = 630''.171$ $g = 9.3$
$\log a = 0.500365$
$e = 0.278198$ Red. to (1918.0)

$$\left.\begin{aligned} i &= 16^\circ\,40'\,19''.9 \\ \Omega &= 60\;\;55\;\;30\;.4 \\ \omega &= 297\;\;\;2\;\;14\;.2 \end{aligned}\right\}1917.0 \qquad \begin{aligned} &+\;0''.2 \\ &+48\;.8 \\ &+\;1\;.5 \end{aligned}$$

CONSTANTS FOR EQUATOR

$$\left.\begin{aligned} x &= r[9.985899]\sin(\;86^\circ\,54'\,20''.2+v) \\ y &= r[9.934848]\sin(\;\;5\;\;43\;\;\;8\;.2+v) \\ z &= r[9.753981]\sin(334\;\;49\;\;58\;.3+v) \end{aligned}\right\}(1917.0)$$

$$\left.\begin{aligned} x &= r[9.985895]\sin(\;86^\circ\,55'\,11''.1+v) \\ y &= r[9.934865]\sin(\;\;5\;\;43\;\;59\;.1+v) \\ z &= r[9.753954]\sin(334\;\;50\;\;29\;.7+v) \end{aligned}\right\}(1918.0)$$

A careful examination for observations of this asteroid in previous oppositions will be undertaken. It is therefore desired that any observations at this opposition yielding an accurate position, especially those on plates taken before discovery, be communicated in detail to the U. S. Naval Observatory as soon as reductions can be made. An ephemeris for the entire opposition follows:

EPHEMERIS.

G. M. T. 1917	α (1917.0) h m s	Daily Var. s	δ (1917.0) ° ′	Daily Var. ′	Log r	Log ρ	Mag.
June 20.5	1 56 31	. . . .	− 1 44.4	. . . . .	0.3589	0.4071	13.1
30.5	2 12 21	+92.6	− 0 19.4	+8.12	.3594	.3905	13.0
July 10.5	2 27 20	87.2	+ 0 57.8	7.31	.3602	.3727	13.0
20.5	2 41 20	80.6	2 6.7	6.47	.3612	.3536	12.9
30.5	2 54 7	72 6	3 7.2	5.64	.3625	.3332	12.8
Aug. 9.5	3 5 26	63.0	3 59.7	4.85	.3641	.3117	12.7
19.5	3 15 0	51.4	4 44.3	4.10	.3660	.2892	12.6
29.5	3 22 28	37.8	5 22.0	3.46	.3681	.2660	12.5
Sept. 8.5	3 27 29	22.1	5 53.9	2.94	.3705	.2427	12.4
18.5	3 29 43	+ 4.4	6 21.4	2.59	.3731	.2200	12.3
28.5	3 28 54	−14.3	+ 6 46.3	+2.44	0.3759	0.1991	12.2

Ephemeris — (*Continued.*)

G. M. T.	α (1917.0)	Daily Var.	δ (1917.0)	Daily Var.	Log *r*	Log *ρ*	Mag.
1917	h m s	s	° ′	′			
Oct. 8.5	3 24 58	−32.7	+7 10.9	+2.50	0.3789	0.1816	12.1
18.5	3 18 9	48.5	7 37.1	2.79	.3821	.1692	12.1
28.5	3 9 6	59.0	8 7.2	3.26	.3855	.1634	12.0
Nov. 7.5	2 58 52	62.3	8 42.8	3.87	.3890	.1656	12.1
17.5	2 48 44	57.9	9 24.9	4.56	.3927	.1759	12.1
27.5	2 39 55	46.8	10 14.1	5.27	.3964	.1936	12.3
Dec. 7.5	2 33 21	31.5	11 10.2	5.94	.4003	.2172	12.4
17.5	2 29 32	−14.3	12 12.7	6.55	.4043	.2450	12.5
1918 27.5	2 28 36	+ 2.9	13 20.8	7.06	.4084	.2751	12.7
Jan. 6.5	2 30 26	+18.8	+14 33.5	+7.45	0.4125	0.3061	12.9
1917	α (1918.0)		δ (1918.0)				
Dec. 27.5	2 28 39	+ 2.9	+13 21.1	+7.06	0.4084	0.2751	12.7
1918							
Jan. 6.5	2 30 29	18.8	14 33.7	7.45	.4125	.3061	12.9
16.5	2 34 50	33.0	15 49.7	7.73	.4167	.3370	13.1
26.5	2 41 23	45.3	17 8.0	7.89	.4209	.3670	13.2
Feb. 5.5	2 49 51	55.9	18 27.2	7.93	.4252	.3957	13.4
15.5	2 59 56	65.0	19 46.3	7.86	.4295	.4227	13.6
25.5	3 11 25	72.6	21 4.1	7.69	.4338	.4479	13.7
Mar. 7.5	3 24 5	79.2	22 19.7	7.42	.4381	.4712	13.8
17.5	3 37 46	84.8	23 32.2	7.06	.4124	.4926	14.0
27.5	3 52 18	+89.5	24 40.7	+6.62	.4467	.5120	14.1
Apr. 6.5	4 7 34	.....	+25 44.4	...	0.4510	0.5296	14.2

U. S. Naval Observatory, Washington, D. C., 1918 June 4.

NOTE ON THE ORBITAL MOTION OF THE DOUBLE STARS Σ 1306 AND Σ 2052.

By GEORGES VAN BIESBRŒCK.

In *A. J.* 737 Mr. E. Doolittle concludes from an elaborate investigation of the motion in Σ 1306 that the relative orbit can no longer be considered as rectilinear. In the light of recent observations no computations are necessary to show that the relative path is rapidly curving. My unpublished measures here are:

1916.188	129°.7	1″.13	2*n*
1918.218	117 .6	1 .04	2*n*

It is on account of this strong curvature of the orbit that this object was put on the list of double stars to be observed for determinations of mass-ratio (*A. J.* 694).

The star Σ 2052 should be carefully watched at this time. For about thirty years (1830–1860) it has been a wide pair, distance 3″, without appreciable motion. In recent years, however, the distance has been decreasing very rapidly. I find here:

1916.248	62°.4	0″.56	4*n*
1918.401	7 .5	0 .28	4*n*

These measures show that the system is approaching periastron and that it may become a difficult pair at that critical moment.

Yerkes Observatory, June 22, 1918.

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Second Elements and Ephemeris of 1917 W *15*, by E. C. Bower and C. C. Wylie.
Note on the Orbital Motion of the Double Stars Σ 1306 and Σ 2052, by G. Van Biesbrœck.

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ON THE APPARENT APSIDES OF A SATELLITE AS PUBLISHED IN THE *AMERICAN EPHEMERIS* AND *NAUTICAL ALMANAC*,

By W. Auhagen.

According to a manuscript, kindly furnished to me by a former Director Nautical Almanac Office, U. S. Naval Observatory, a set of formulæ for the computation of the apparent apsides of a satellite is used for the annual publication of these phenomena which is based upon the following expressions for the center of the apparent ellipse, *viz.*:

$$\text{(a)}\quad \begin{aligned} s''\cdot\sin(p-P) &= (a\,e)''\cdot\frac{\Delta_0}{\Delta}\cdot\sin(U-\varpi)\\ s''\cdot\cos(p-P) &= -(a\,e)''\cdot\frac{\Delta_0}{\Delta}\cdot\cos(U-\varpi)\cdot\sin B\end{aligned}$$

where B, U, P are the well-known Marthian constants, a, s, ϖ the semi-major axis, excentricity and perihelion distance from the ascending node of the true ellipse; p, s the position angle and distance of the center of the apparent ellipse with regard to the apparent place of the planet, the distance of the latter from the *Earth* being $= \Delta$, while Δ_0 is any conveniently chosen distance, from which viewed the linear distance $a\,e$ has the angular distance $(a\,e)''$. These formulæ are based upon the general expressions for the relation between points of the true and apparent orbit in perspective projection with each other, *viz.*:

$$\text{(1)}\quad \begin{aligned} s''\cdot\sin(p-P) &= r_0''\cdot\frac{\Delta_0}{\Delta}\cdot\sin(u-U)\\ s''\cdot\cos(p-P) &= r_0\cdot\frac{\Delta_0}{\Delta}\cdot\cos(u-U)\cdot\sin B\end{aligned}$$

and are derived from them by putting $r_0'' = (a\,e)''$, $u = 180 + \varpi$. With other words, it is assumed that the center of the apparent ellipse is the perspective projection of the center of the true ellipse. But this evidently holds good only when the view point is at an infinite distance, or when the points are in parallel projection with each other, as, for instance, is practically realized in the case of a double star orbit and its projection upon the visual plane, the plane perpendicular to the visual ray; but the case of a satellite is different. Now squaring the equations (1) and forming their sum we obtain

$$\text{(b)}\quad s^2 = \left(r_0''\cdot\frac{\Delta_0}{\Delta}\right)^2\left[\sin^2(u-U)+\cos^2(u-U)\cdot\sin^2 B\right]$$

and r is then assumed to conform itself to the *somewhat curtailed* central equation of the true ellipse

$$\text{(c)}\quad \left(\frac{r}{a}\right)^2\left[\cos^2(u-\varpi)+\frac{\sin^2(u-\varpi)}{1-e^2}\right]=1$$

$$\left(\text{the exact equation is } \left(\frac{r}{a}\right)^2\left[\cos^2(u-\varpi)+\frac{\sin^2(u-\omega)}{1-e^2}\right] + \frac{2r\cdot a\,e}{a^2}\cdot\cos(u-\varpi)+e^2=1.\right)$$

and for s to be a maximum there results after considerable manipulation rigorously the following interesting equation for u

$$\text{(d)}\quad \cos\left(2u+M-(U+\varpi)\right)=\frac{1}{m}$$

where m and M are given by

$$\left.\begin{aligned} m\cdot\sin M &= \frac{\operatorname{cotg}^2\varphi-\operatorname{tg}^2 B}{\sin(U-\varpi)}\\ m\cdot\cos M &= \frac{\operatorname{cotg}^2\varphi+\sec^2 B}{\cos(U-\varpi)}\end{aligned}\right\}\quad\text{(e)}$$

I admit that I have not yet, after repeated efforts, succeeded to grasp the underlying idea of this combination of formulæ which at best may claim for its justification a certain elegance and a convenient form of the final result to which it leads. But from my standpoint I consider the entire process impossible, and therefore have made an effort to solve the problem rigorously in the following manner. I state two methods, both of which are based upon the initial complete determination of the apparent orbit of the satellite, which will be available at any time from the known elements of the true orbit.

For five different times, conveniently chosen, five corresponding values of $s \cdot \sin p = x$ and $s \cdot \cos p = y$ are computed by means of the general expressions (1) which yield

$$(2)\quad \begin{aligned} x &= s \cdot \sin p = r_0'' \cdot \frac{\Delta_0}{\Delta}\,[\sin(u - U) \cdot \cos P \\ &\qquad + \cos(u - U) \cdot \sin B \cdot \sin P] \\ y &= s \cdot \cos p = r_0 \cdot \frac{\Delta_0}{\Delta}\,[-\sin(u - U) \cdot \sin P \\ &\qquad + \cos(u - U) \cdot \sin B \cdot \cos P] \end{aligned}$$

I determine by means of these five places the constants a, b, c, d, e of the equation of the apparent orbit

$$(3)\qquad ax^2 + b \cdot y^2 + c \cdot xy + dx + ey + 1 = 0$$

We then have, as is well known, for the coördinates of the center of the apparent ellipse in form of position angle and distance with respect to the apparent place of the planet

$$(4)\quad \begin{aligned} tg\ p_0 &= \frac{ce - 2bd}{cd - 2ae}\,. \\ s_0 &= \frac{1}{4ab - c^2}\sqrt{[(ce - 2bd)^2 + (cd - 2ac)^2]} \end{aligned}$$

The axes of the apparent ellipse will be

$$(5)\qquad A^2 = \frac{B^2}{g^2}\,,\quad B^2 = \frac{2}{(4ab - c^2)\,(a + b - f)}\,. \\ \sqrt{ae^2 + bd^2 - cde - (4ab - c^2)}$$

where

$$(6)\qquad g = \sqrt{\frac{a + b + f}{a + b - f}}\ ;\ f = \sqrt{c^2 + (b - a)^2}$$

is, as to its sign, subject to the condition that $+ 2f$ and $a + b - f$ must be of opposite sign, evidently because the square of the excentricity of the apparent ellipse is given by

$$c^2 = \frac{-2f}{a + b - f} \qquad (7)$$

Finally we have for the inclination of the major axis of the apparent ellipse to the axis of x the expression

$$\mathrm{tg}\,\varphi_0 = \frac{b - a + f}{c}\,. \qquad (8)$$

Extending now the fundamental formulæ (1) to any two points in the planes of the true and apparent orbit of the satellite in perspective projection with each other, the distance ρ_0 and the argument of latitude u_0 of *that* point in the plane of the true orbit the perspective projection of which is the center of the apparent orbit evidently follow from

$$\begin{aligned} \rho_0'' \cdot \sin(u_0 - U) &= s_0'' \cdot \frac{\Delta_0}{\Delta} \cdot \sin(p_0 - P) \\ \rho'' \cdot \cos(u_0 - U) &= \cdot s_0'' \cdot \frac{\Delta_0}{\Delta} \cdot \cos(p_0 - P) \cdot \mathrm{cosec}\, B\,. \end{aligned} \qquad (9)$$

This point ρ_0, u_0 in the plane of the true orbit I shall henceforth refer to as point C_0. It is thus determined within the limits of accuracy underlying the fundamental formulæ (1), where all quantities of the order $\left(\frac{r}{\Delta}\right)^2$ and of higher orders are rejected. This point C_0 will now take the place of the planet; it becomes therefore necessary to recompute the Marthian constants so as to suit the change in the point of reference from the planet to the point C_0.

Let σ_0 be the angle which, at the planet, the line Earth-Planet or Δ produced makes with the line Planet-point C_0 or ρ_0, then

$$\begin{aligned} \sin\sigma_0 \cdot \sin(p_0 - P) &= \sin(u_0 - U) \\ \sin\sigma_0 \cdot \cos(p_0 - P) &= \cos(u_0 - U) \cdot \sin B \qquad (10) \\ \cos\sigma_0 &= \cos(u_0 - U) \cdot \cos B \end{aligned}$$

We have next for the right ascension α_0' and declination δ_0' of the center of the apparent ellipse, that is also of the point C_0

$$\begin{aligned} \cos\delta_0' \cdot \sin(\alpha_0' - \alpha) &= \sin s_0 \cdot \sin p_0 \\ \cos\delta_0 \cdot \cos(\alpha_0' - \alpha) &= \cos s_0 \cdot \cos\delta - \sin s_0 \cdot \sin\delta \cdot \cos p_0 \qquad (11) \\ \sin\delta_0 &= \cos s_0 \cdot \sin\delta + \sin s_0 \cdot \cos\delta \cdot \cos p_0 \end{aligned}$$

where α, δ refer to the planet.

If further B_0 the elevation of the *Earth* above the plane of the true orbit viewed from the point C_0, and

P_0 the position angle at the point C_0, of the pole of the plane of the true orbit of the satellite, then obviously:

(12)

$$\cos B_0 \cdot \sin P_0 = -\sin I \cdot \cos(\alpha_0' - N)$$
$$\cos B_0 \cdot \cos P_0 = \cos I \cdot \cos \delta_0' + \sin I \cdot \sin \delta_0' \cdot \sin(\alpha_0' - N)$$
$$\sin B_0 = -\cos I \cdot \sin \delta_0' + \sin I \cdot \cos \delta_0' \cdot \sin(\alpha_0' - N)$$

where I, N the inclination and node of the true orbit upon the fundamental plane, to which the Marthian constants refer. Let finally W_0 the argument of latitude of *that* point in the plane of the true orbit which is in upper geocentric conjunction with the point C_0, we must have

(13)

$$\cos B_0 \cdot \cos W_0 = \cos \delta_0' \cdot \cos(\alpha_0' - N)$$
$$\cos B_0 \cdot \sin W_0 = \sin \delta_0' \cdot \sin I + \cos \delta_0 \cdot \cos I \cdot \sin(\alpha_0' - N)$$

The Marthian constants B, U, P referring to the planet as center of motion are now replaced by similar constants B_0, W_0, P_0, which afford to state the position angle π and distances of the satellite with regard to the center of the apparent ellipse by the expressions

$$(14)\qquad \begin{aligned} S_0'' \cdot \sin(\pi - P_0) &= \rho'' \cdot \frac{\Delta_0}{\Delta'} \cdot \sin(w - W_0) \\ S_0'' \cdot \cos(\pi - P_0) &= \rho'' \cdot \frac{\Delta_0}{\Delta'} \cdot \cos(w - W_0) \cdot \sin B_0 \end{aligned}$$

where (cf. Diagr. I) ρ the distance of the satellite S from the point C_0, and Δ' the distance of the *Earth E* from the point C_0, or

$$(15)\qquad \Delta'^2 = \Delta^2 + \rho_0^2 + 2s\rho_0 \cdot \cos \sigma_0 \,,$$

and where w is the angle, at the point C_0, which ρ makes with the line of node through C_0, which will be parallel to the line of node N through the planet. If now in (14) we put S_0'' equal to the semi-major axis A (in arc) of the apparent orbit, and π equal to the angle $90 - \varphi_0'$ which A makes with the meridian through C_0, and where φ_0' follows from

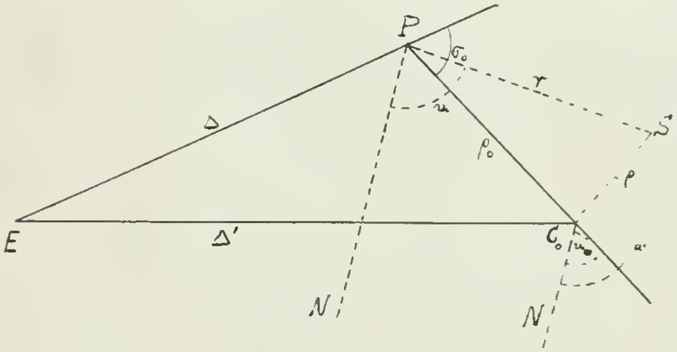


Fig I

$$\begin{aligned} \cos \varphi_0' \cdot \cos \delta_0' &= \cos \varphi_0 \cdot \cos \delta \\ \sin \varphi_0' \cdot \cos \delta_0' &= -\sin \delta \cdot \sin s_0 + \cos \delta \cdot \cos s_0 \cdot \sin \varphi_0 \end{aligned} \qquad (16)$$

though in most cases it will be sufficiently accurate to put $\varphi_0' = \varphi_0$, we shall have ρ and w corresponding to the apparent apsidal point and referring to the point C_0

$$\begin{aligned} \rho'' \cdot \sin(w - W_0) &= A \cdot \frac{\Delta'}{\Delta} \cdot \cos(\varphi' + P_0) \\ \rho'' \cdot \cos(w - W_0) &= A \cdot \frac{\Delta'}{\Delta} \cdot \sin(\varphi' + P_0) \cdot \operatorname{cosec} B_0 \end{aligned} \qquad (17)$$

and referring back to the planet, as is obvious from the diagram,

$$\begin{aligned} r \cdot \sin(u - u_0) &= \rho \cdot \sin(w - u_0) \\ r \cdot \cos(u - u_0) &= \rho \cdot \cos(w - u_0) + \rho_0 \end{aligned} \qquad (18)$$

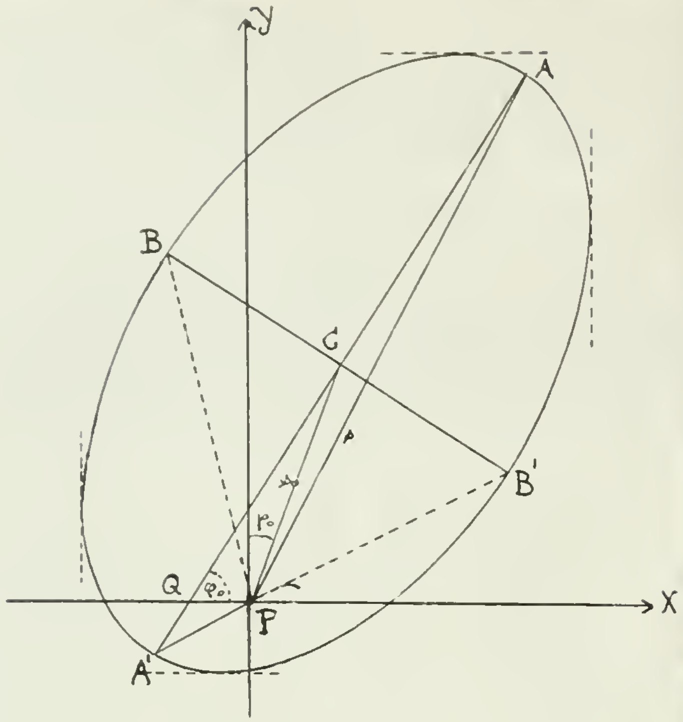
This value of u then leads to the time t of the apparent apside by means of

$$\begin{aligned} v &= u - \varpi \\ \operatorname{tg} \tfrac{1}{2}E &= \sqrt{\frac{1 - e}{1 + e}} \cdot \operatorname{tg} \tfrac{1}{2}v \\ t &= t_0 + \frac{1}{\mu} \cdot (E - e \sin E) \end{aligned} \qquad (19)$$

This whole computation may be carried on as rigorously as desired without conceding anything for the sake of convenience of computation, as the *Nautical Almanac* formulæ do; convenience should always stand second in the order of consideration, the truth ranks first.

The second method which I shall propose, is shorter in as much as it does not require any modification of the Marthian constants B, U, P and, therefore, no reduction of an extra-focal angle w to the argument of latitude u of the satellite.

Let (cf. Diagr. II) A, B, A', B' the apparent ellipse referred to the axis x at right angle to the axis y which latter may be the meridian line through the apparent place P of the planet. We have then as the known quantities



$$CA = CA' = A\ ;\ \ CB = CB' = B\ ;\ \ PC = s_0\ ;\ \ \angle yPC = p_0\ ;$$
$$\angle CQP = \varphi_0\ ;$$

hence the following set of angles all of which situated in the plane of the apparent orbit

$$(20)\qquad \begin{aligned} \angle\ QCP &= 90^\circ - (p_0 + \varphi_0) \\ \angle\ ACP &= 90^\circ + (p_0 + \varphi_0) \\ \angle\ BCP &= 180^\circ - (p_0 + \varphi_0) \\ \angle\ B'CP &= p_0 + \varphi_0 \end{aligned}$$

If now p designates a variable position angle, and s likewise a variable distance of the points A, B, A', B' from the planet P, then we have, with respect to the apparent place of the planet as point of reference

$$(21)\qquad \begin{aligned} s \cdot \sin\,(p - p_0) &= \pm A \cdot \cos\,(p_0 + \varphi_0) \\ s \cdot \cos\,(p - p_0) &= \pm A \cdot \sin\,(p_0 + \varphi_0) + s_0 \end{aligned}$$

and

$$(22)\qquad \begin{aligned} s \cdot \sin\,(p - p_0) &= \pm B \cdot \sin\,(p_0 + \varphi_0) \\ s \cdot \cos\,(p - p_0) &= \pm B \cdot \cos\,(p_0 + \varphi_0) + s_0 \end{aligned}$$

where the upper signs refer to the points A and B, the lower signs to the points A' and B'.

With these values of s and p for points of the apparent orbit we easily obtain the values of u and r from the general equations (1) for those points of the true orbit which are in perspective projection with the points A, B, A', B' respectively and then the times of the apparent apsides as shown before.

In connection with the times of the apparent apsidal and conjugate points there may also be a demand for those points of the apparent orbit, in which the satellite attains its greatest difference in right ascension or in declination from the planet, which, for short, I shall call points of greatest elongation east and west, or north and south respectively of the planet, and which differ from the points of greatest elongation as commonly understood. We have, in order to solve this problem:

$$\text{tg}\ (\alpha' - \alpha) = \frac{(s \cdot \sin\,p)\ \sec\,\delta}{1 - (s \cdot \cos\,p) \cdot \text{tg}\ \delta} \qquad (23)$$

and the required times are obtained for those values of the argument u of the satellite for which

$$\frac{\partial\,\text{tg}\,(\alpha' - \alpha)}{\partial u} = \cos\delta \cdot \frac{\partial(s \cdot \sin p)}{\partial u} - \sin\delta \cdot (s \cdot \cos p)\,\frac{\partial(s \cdot \sin p)}{\partial u}$$
$$+ \sin\delta \cdot (s \cdot \sin p) \cdot \frac{\partial(s \cdot \cos \rho)}{\partial u} = 0$$

Since

$$s'' \cdot \sin p = r'' \cdot \frac{\Delta_0}{\Delta} \cdot [\cos P \cdot \sin\,(u - U)$$
$$+ \sin B \cdot \sin P \cdot \cos\,(u - U)]$$

$$s'' \cdot \cos\,p = r'' \cdot \frac{\Delta_0}{\Delta} \cdot [-\ \sin\,P \cdot \sin\,(u - U)$$
$$+ \sin\,B \cdot \cos\,P \cdot \cos\,(u - U)]$$

we are led, after considerable reduction, to the expression

$$\cos\,\delta\ [\cos P \sin\,(u - U) + \sin B \sin P \cos\,(u - U)]\ \frac{\partial r_0''}{\partial u}$$
$$+ r''_0 \cdot \cos\delta\,[\cos P \cos\,(u - U) - \sin B \sin P \cdot \sin\,(u - U)]$$
$$-\ r_0''^2\,\frac{\Delta_0}{\Delta} \cdot \sin\delta \cdot \sin B = 0$$

But

$$r_0'' = \frac{a}{\Delta_0 \cdot \sin 1''} \cdot \frac{1 - e^2}{1 + e\,\cos\,(u - \varpi)}\ ,$$

$$\therefore \frac{\partial r_0}{\partial u} = \frac{r_0''^2 \cdot e \cdot \sin \cdot (u - \pi)}{\dfrac{a}{\Delta_0 \cdot \sin 1''}\,(1 - e^2)}$$

hence dividing by r_0'' and $\frac{\Delta_0}{\Delta}$, we get

$$\begin{aligned} &\cos P \cdot \cos(u - U) - \sin B \sin P \cdot \sin(u - U) \\ &= e\,[-\cos P \cdot \cos(\varpi - U) + \sin B \sin P \cdot \sin(\varpi - U)] \\ &\qquad\qquad + \frac{a}{\Delta}(1 - e^2) \cdot \operatorname{tg} \delta \cdot \sin B \\ &= k, \text{ say.} \end{aligned}$$

k being a constant; let now

$$(24)\qquad \frac{\cos P}{k} = m \quad , \quad -\frac{\sin B \sin P}{k} = n$$

$$\therefore\ m \cdot \cos(u - U) + n \cdot \sin(u - U) - 1 = 0$$

This equation I solve for u directly in the following manner. Let h and H satisfy the conditions

$$(25)\qquad \begin{aligned} h \cdot \sin H &= m \cos u + n \cdot \sin u \\ h \cdot \cos H &= -n \cos u + m \cdot \sin u \end{aligned}$$

then, since we must have

$$h = \pm \sqrt{m^2 + n^2}$$

the last equation (24) assumes the form

$$(26)\qquad \sin(H + U) = \pm \frac{1}{\sqrt{m^2 + n^2}}$$

from which we find H, and with respect to the values of m and n we get from (25)

$$(27)\qquad \left\{ \begin{aligned} \sin u &= \frac{1}{\sqrt{m^2 + n^2}}(m \cos H + n \sin H) \\ &= \pm \frac{\cos P \cdot \cos H - \sin B \cdot \sin P \cdot \sin H}{\sqrt{1 + \cos^2 B \cdot \sin^2 P}} \\ \cos u &= \frac{1}{\sqrt{m^2 + n^2)}}(m \cdot \sin H - n \cos H) \\ &= \pm \frac{\cos P \cdot \sin H + \sin B \cdot \sin P \cdot \cos H}{\sqrt{1 + \cos^2 B \cdot \sin^2 P}} \end{aligned} \right.$$

These equations yield four values of u, of which only two will be admissible. These substituted in the general equation (1) give the position angle and distance for which the satellite is at its greatest eastern and western elongation from the planet; the corresponding times are given by (19).

The points of the apparent orbit in which the satellite is at its greatest northern and southern distance from the planet I easily derive from the expression given by Marth for $\delta' - \delta$, *viz.*:

$$\delta' - \delta = \frac{r}{\Delta} \cdot \omega'' \cdot \left(\frac{y}{r}\right) \left\{ 1 - \frac{r}{\Delta} \left[\frac{2}{r} + \left(\frac{x}{r}\right)^2 + \frac{x^2}{r \cdot y} \cdot \operatorname{tg} \delta \right] \right\}$$

where x, y, z the planetocentric coördinates of the satellite. Neglecting all terms of the order $\left(\frac{r}{\Delta}\right)^2$ and higher, we get

$$\delta' - \delta = \frac{y}{\Delta} \cdot \omega''$$

But

$$\begin{aligned} y = r \cdot \sin \sigma \cdot \cos p = r\,[&-\sin P \cdot \sin(u - U) \\ &+ \sin B \cdot \cos P \cos(u - U)] \end{aligned}$$

Since for the points in question we must have

$$\frac{\partial(\delta' - \delta)}{\partial u} = 0,$$

we finally get

$$\begin{aligned} &\sin P \cdot \cos(u - U) + \sin B \cdot \cos P \cdot \sin(u - U) \\ &\quad = e\,[\sin B \cos P \cdot \sin(U - \varpi) - \sin P \cos(U - \varpi)] \\ &\quad = K, \text{ say} \end{aligned}$$

where K is a known constant.

If now we put:

$$\left. \begin{aligned} &\frac{\sin P}{K} = \mu \quad , \quad \frac{\sin B \cdot \cos P}{K} = v \\ &\text{we get} \\ &\mu \cos(u - U_0) + v \cdot \sin(u - U_0) - 1 = 0 \end{aligned} \right\} \quad (28)$$

to which equation for u the process of solution may be applied which I proposed to the equation (24).

These two equations (24) and (28) range themselves

If in Equation (24) the substitution be made, as would seem natural at a first glance, *viz.*

$$\begin{aligned} m \sin U + n \cos U &= g \sin G \\ m \cos U - n \sin U &= g \cos G \end{aligned}$$

so that g and G become constants, then (24) gives

$$\cos(u - G) = \frac{1}{g}$$

from which the two values of u required follow directly; this is a simple way of solving (24), but my aim was to develop an expression for $\sin u$ and $\cos u$ separately without solving the equation as one of the fourth degree in $\sin u$ or $\cos u$.

well alongside of the well-known equation for the greatest elongation of the satellite as commonly understood. It is given already by ENCKE (cf. *B. J.* 1832) and is, transformed so as to involve the Marthian constants,

$$(29)\quad \begin{cases} \dfrac{m}{\sin(u-U)} + \dfrac{n}{\cos(u-U)} - 1 = 0 \\ \text{where} \\ m = e\,\mathrm{tg}^2 B\cdot\sin(u-\varpi)\,,\quad n = e\sec^2 B\cdot\cos(U-\varpi) \end{cases}$$

Though this equation is more complicated than the former two it is easily and conveniently solved by putting

$$m\cos u + n\sin u = h\cos H$$
$$m\sin u - n\cos u = h\sin H$$

which give first

$$\sin 2u = \frac{1}{m^2+n^2}\left[(m^2-n^2)\cdot\sin 2H + 2mn\cdot\cos 2H\right]$$

$$\cos 2u = \frac{1}{m^2+n^2}\left[(m^2-n^2)\cdot\cos 2H - 2m\cdot n\cdot\sin 2H\right]$$

If we now put

$$\frac{m^2-n^2}{(m^2+n^2)^{3/2}} = g\sin 2G\ ,\quad \frac{2m\cdot n}{(m^2+n^2)^{3/2}} = g\cos 2G$$

we get as the above equation transformed

$$\cos(H-U) = \tfrac{1}{2}\,g\cos 2\,(H-U-G)$$

which is easily solved for H, hence $2u$ and u become known.

Broderick, Cal., May, 1918.

OCCULTATIONS BY THE MOON,

OBSERVED WITH THE 26-INCH AND 12-INCH EQUATORIALS OF THE U. S. NAVAL OBSERVATORY.

[Communicated by Admiral T. B. HOWARD, U. S. N., Superintendent.]

Date	Object		26-inch					12-inch				
			W. Sid. T.	W. M. T.	Seeing	Power	Obs.	W. Sid. T.	W. M. T.	Seeing	Power	Obs.
1917			h m s	h m s				h m s	h m s			
Oct. 21	24 *Sagittarii*	RB	19 26 33.6	5 27 22.8	p (1)	178	Hl	19 26 26.3	5 27 15.5	vp(1)	160	Bn
	117 *B. Sagittarii*	DD	21 23 20.6	7 23 50.7	vp(2)	183	Hl	21 23 20.6	7 23 50.7	vp(2)	235	Bn
	117 *B. Sagittarii*	RB	....	....	...	..	..	22 31 40.8	8 31 59.7	vp	160	Bn
Oct. 24	72 *B Aquarii*	DD	21 59 47.7	7 48 24.2	p (3)	183	Hl	21 59 47.8	7 48 24.3	vp(4)	115	Bn
Nov. 2	3 *Geminorum*	DB	2 19 2.5	11 31 33.3	f (5)	178	Hl	2 18 59.9	11 31 30.7	f (5)	160	Bn
	3 *Geminorum*	RD	3 16 58.7	12 29 20.0	f	183	Hl	3 16 58.7	12 29 20.0	f	115	Bn
Nov. 3	120 *B. Geminorum*	DB	5 27 18.9	14 35 22.9	f (5)	250	Hl	5 27 17.2	14 35 21.2	f (6)	160	B
	120 *B. Geminorum*	RD	6 39 52.1	15 47 44.2	f (7)	183	Hl	6 39 52.1	15 47 44.2	f (7)	115	B
Nov. 28	300 *B. Tauri*	DB	4 14 8.0	11 44 6.2	p (8)	250	Hl	4 13 58.0	11 43 56.3	p (9)	160	Bn
	300 *B. Tauri*	RD	....	....	.....		.	4 46 16.3	12 16 9.3	p (10)	160	Bn
Dec. 6	*ι Leonis*	DB	7 8 5.1	14 6 7.6	f (11)	250	Hl	7 8 5.1	14 6 7.6	p (12)	160	B
	ι Leonis	RD	7 42 17.3	14 40 14.2	f (13)	183	Hl	....	....	.....	..	..
Dec. 27	3 *Geminorum*	RB	....	....	.....	..	.	0 54 2.4	6 30 31.9	p	160	Bn
	6 *Geminorum*	DD	1 9 7.3	6 45 34.4	f (14)	178	Hl	1 9 7.1	6 45 34.2	p (5)	160	Bn
1918	6 *Geminorum*	RB	2 5 41.4	7 41 59.2	f	178	Hl	2 5 54.1	7 42 11.9	p (15)	160	Bn
Jan. 19	20 *H' Arietis*	DD	4 46 54.8	8 52 20.3	p (16)	183	Hl	4 46 54.8	8 52 20.3	f (17)	235	Bn
Jan. 21	161 *B. Tauri*, comp. pr. s.	DD	3 22 4.6	7 19 52.1	f	178	Hl	....	....	.....	...	..
	161 *B. Tauri*, comp. f. s.	DD	3 25 15.2	7 23 2.2	f	178	Hl	....	....	.....	...	..
	161 *B. Tauri*	DD	3 25 17.4	7 23 1.1	f (7)	178	Hl	3 25 17.1	7 23 4.1	f	235	Bn
Jan. 22	99 *Tauri*	DD	2 28 8.8	6 22 9.2	p (18)	178	Hl	2 28 8.5	6 22 8.9	f (19)	115	B
	99 *Tauri*	RB	3 49 36.8	7 13 23.9	vp (29)	178	Hl	....	....	.....	...	..
Feb. 18	300 *B. Tauri*	DD	5 46 7.4	7 53 25.8	f (2	250	Hl	5 46 7.5	7 53 25.9	f (21)	235	Bn
	300 *B. Tauri*	RB	7 9 17.9	9 16 22.7	g (22)	178	Hl	7 9 16.1	9 16 20.9	f (23)	160	Bn

Date	Object		26-inch					12-inch				
			W. Sid. T.	W. M. T.	Seeing	Power	Obs.	W. Sid. T.	W. M. T.	Seeing	Power	Obs.
1917			h m s	h m s				h m s	h m s			
Feb. 26	*e Leonis*	DB	11 54 46.5	13 29 37.3	f	178	Hl	11 54 47.0	13 29 37.8	p (5)	160	Bn
	e Leonis	RD	13 16 15.7	14 50 53.1	f	178	Hl	13 16 15.8	14 50 53.2	f	160	Bn
Feb. 28	370 *B. Virginis*	RD	9 13 55.8	10 41 21.1	p (24)	183	Hl	9 13 56.1	10 41 21.4	p (25)	160	Bn
Mar. 1	83 *Virginis*	DB	11 6 58.1	12 30 9.1	p (26)	178	Hl	11 6 58.6	12 30 9.6	vp(27)	160	B
	83 *Virginis*	RD	12 19 22.8	13 42 21.9	f	178	Hl	12 19 22.9	13 42 22.0	p (19)	160	B
Mar. 17	72 *Tauri*	DD	....	....	.....	...	..	7 26 6.8	7 46 59.4	f (17)	115	Bn
	72 *Tauri*	RB	....	....	.....	...	..	8 33 21.1	8 54 2.7	p	160	Bn
Mar. 19	*μ Geminorum*	DD	7 18 11.3	7 31 13.4	f (28)	183	Hl	7 18 11.4	7 31 13.5	g (29)	115	Bn
	μ Geminorum	RB	8 28 47.7	8 41 38.2	f (30)	178	Hl	....	....	.....	...	..
Mar. 28	75 *Virginis*	DB	14 12 4.6	13 48 35.7	f	178	Hl	14 12 0.5	13 48 31.6	f (5)	160	Bn
	75 *Virginis*	RD	15 0 16.5	14 36 39.7	f (7)	178	Hl	....	....	.....	...	..
Mar. 29	43 *H. Virginis*	DB	9 50 55.0	9 24 13.0	p (20)	178	Hl	9 50 57.9	9 24 15.9	p (5)	160	Bn
	43 *H. Virginis*	RD	10 52 3.0	10 25 11.0	(31)	178	Hl	10 52 3.0	10 25 11.0	f	160	Bn
	236 *G. Virginis*	DB	12 28 56.1	12 1 48.2	f	178	Hl	12 29 1.1	12 1 53.2	f (5)	160	Bn
	236 *G. Virginis*	RD	12 59 1.1	12 31 48.3	g	178	Hl	12 59 1.1	12 31 48.3	f	160	Bn
Mar. 31	57 *B. Scorpii*	DB	14 40 20.9	14 4 59.7	p	178	Hl	14 40 16.3	14 4 55.1	p (5)	160	Bn
	57 *B. Scorpii*	RD	16 10 36.6	15 35 0.6	p (32)	183	Hl	16 10 36.7	15 35 0.7	p	115	Bn
	27 *G. Scorpii*	DB	16 29 3.7	15 53 24.7	p (33)	178	Hl	16 29 3.0	15 53 24.0	p (5)	160	Bn
	27 *G. Scorpii*	RD	17 58 43.8	17 22 50.1	f (34)	183	Hl	17 58 43.7	17 22 50.0	p (35)	115	Bn
Apr. 2	4 *Sagittarii*	DB	16 27 40.1	15 44 9.4	f (17)	178	Hl	....	....	.....	...	..
Apr. 4	57 *Sagittarii*	DB	16 13 0.3	15 21 40.3	vp(33)	178	Hl	16 13 7.7	15 21 47.7	p (5)	160	Bn
	57 *Sagittarii*	RD	17 9 50.3	16 18 21.0	f (36)	183	Hl	17 9 50.3	16 18 21.0	p	115	Bn
Apr. 15	141 *Tauri*	DD	8 37 26.4	7 4 6.0	f (37)	183	Hl	8 37 26.3	7 4 5.9	g (2)	115	Bn
	141 *Tauri*	RB	....	....	.....	...	..	9 31 49.1	7 58 19.8	f	160	Bn
	14 *B. Geminorum*	DD	12 11 36.6	10 37 41.1	p (2)	183	Hl	12 11 36.6	10 37 41.1	p	115	Bn
Apr. 22	13 *B. Virginis*	DD	16 27 50.2	14 25 41.4	p (38)	178	Bn	16 27 50.4	14 25 41.6	p (32)	160	B
May 19	*e Leonis*	DD	13 14 20.1	9 26 33.4	f (32)	183	Hl	13 14 20.3	9 26 33.6	g	115	Bn
	e Leonis	RB	13 54 14.8	10 6 21.6	g (39)	178	Hl	13 54 8.0	10 6 14.8	g	160	Bn
22	83 *Virginis*	DD	11 57 56.1	7 58 34.2	f	178	Hl	11 57 56.0	7 58 34.1	p (17)	160	Bn
May 26	191 *B. Ophiuchi*	DB	17 6 56.5	12 51 0.3	p	178	Hl	17 6 52.3	12 50 56.2	p (40)	160	Bn
	191 *B. Ophiuchi*	RD	18 30 13.0	14 14 3.2	f (41)	178	Hl	18 30 13.0	14 14 3.2	p (29)	160	Bn
	b Ophiuchi	DB	17 55 11.6	13 39 7.5	p	178	Hl	17 55 13.8	13 39 9.7	p (40)	160	Bn
June 19	45 *H. Virginis*	RB	14 5 42.7	8 15 54.3	f	178	Hl	....	....	.....	...	..
	231 *G. Virginis*	DD	14 15 53.8	8 26 3.8	f (7)	183	Hl	14 15 53.6	8 26 3.6	f	160	Bn
	231 *G. Virginis*	RB	15 42 56.0	9 52 51.7	f (31)	178	Hl	....	....	.....	...	..
	236 *G. Virginis*	DD	15 26 21.4	9 36 19.8	p	183	Hl	15 26 21.4	9 36 19.8	p	160	Bn
	236 *G. Virginis*	RB	16 51 14.1	11 0 58.6	f (31)	178	Hl	16 51 13.0	11 0 57.5	p	160	Bn
June 23	4 *Sagittarii*	DD	16 51 37.5	10 45 38.3	f (14)	178	Hl	16 51 37.6	10 45 38.4	p	160	Bn
	4 *Sagittarii*	RB	18 8 5.9	12 1 54.2	p (31)	178	Hl	18 8 1.6	12 1 49.9	p	160	Bn
June 27	c^2 *Capricorni*	DB	18 23 57.8	12 1 59.9	f (42)	178	Hl	18 24 0.1	12 2 2.2	p (43)	160	Bn
	c^2 *Capricorni*	RD	19 31 55.1	13 9 46.1	g (7)	183	Hl	19 31 55.1	13 9 46.1	p (17)	115	Bn

DD = disappearance at dark limb. DB = disappearance at bright limb. RD = reappearance at dark limb. RB = reappearance at bright limb. Under "Seeing," g = good, f = fair, p = poor, vp = very poor; numerals refer to "Remarks." Occulting bars were attached to eyepieces of powers 250, 178 and 160. Except as noted under remarks all observations recorded on chronograph.

Observers: Hl = A. Hall. Bn = H. E. Burton. B = Ernest Clare Bower.

REMARKS

(1) Twilight. Late on 26-inch. (2) Dark limb visible. Disappearance gradual with 26-inch on October 21. (3) Clouds. (4) Thin clouds. Windy. (5) Gradual. (6) $\pm 0^{s}.3$. (7) Late $0^{s}.2$. (8) Uncertain.

Fog and haze. (9) Gradual. Haze. (10) Uncertain. Haze. (11) Eye and ear. (12) Late 2^s ± 3^s. (13) Clouds: could not tell whether reappeared from clouds or dark limb. (14) Moon near full. (15) Late. Thin clouds. (16) Late 0^s.1. Haze. (17) Haze. (18) Late 0^s.2. Eyepiece fogged. (19) Late 0^s.15. (20) Limb boiling. (21) Good disappearance. (22) Late 2^s. (23) Late. Haze. (24) Late? Haze. (25) Haze. Star faint. (26) Uncertain. Moon's limb boiling. (27) ±5^s. (28) Disappearance through clouds. (29) Thin clouds. (30) Late several seconds. Through clouds. (31) Late. (32) Late 0^s.1. (33) Early. (34) Late 0^s.1. Thin clouds. Twilight. (35) Dawn. (36) Late 0^s.1. Dark limb visible. (37) Early 0^s.1. Twilight. Dark limb visible. (38) Time uncertain. Perhaps out by ±0^s.1. Haze. (39) Late 2^s. Clock running slow. (40) Time uncertain. Gradual. (41) Clouds over moon. (42) Haze and clouds. (43) Gradual. Thin clouds.

1918, July 19.

OBSERVATIONS OF *NOVA AQUILÆ* NO. 3,

MADE WITH THE 26-INCH EQUATORIAL, THE 9-INCH TRANSIT-CIRCLE, AND THE 5-INCH ALT-AZIMUTH OF THE U.S. NAVAL OBSERVATORY.

[Communicated by Rear Admiral T. B. HOWARD, U. S. Navy, Superintendent.]

Date Wash. M. T.	Comp.	$\Delta\alpha$	$\Delta\delta$	App. α	App. δ	Red. to App. Pl.		Est. Mag.	See'g	Obs.
1918 h m s		s	′ ″	h m s	° ′ ″	s	″	M		
June 9 10 33 33	4 , 4	+13.77	+3 37.5	18 44 47.09	+0 29 33.7	+3.63	+3.0	−0.3	fair	H
11 10 5 48	4 , 4	+13.77	+3 37.6	18 44 47.13	+0 29 34.0	+3.67	+3.2	+0.5	poor	H

Mean Place of Comparison Star for 1918.0

α	δ	Authority
18^h 44^m 29^s.69	+0° 25′ 53″.2	*A. G. Nicolajew* 4685

NOTES.

W. M. T.
June 12.5 H. *Nova Aquilæ* appears to be a trifle brighter than *Altair*.
12.5 Bn. *Nova Aquilæ* appears to be about as bright as *Altair* but not quite so blue in color.
13.5 H. *Nova Aquilæ* appears to be a little less bright than *Altair* at 16^h G. M. T.
15.5 H. *Nova Aquilæ* about 0.5 mag. fainter than *Altair* at 16^h 20^m G. M. T.

The *Nova* appears as a star of the 11th magnitude on the *Carte Photographique du Ciel of Algiers, zone +1°, No. 141.*

Five observations on the 9-inch Transit-Circle gave the following position of *Nova Aquilæ* referred to Newcomb's positions of the clock stars:

Epoch	α(1918.0)	Prec.	Sec. Var.	δ(1918.0)	Prec.	Sec. Var.
1918.46	18^h 44^m 43^s.514	+3^s.0614	−0^s.0005	+0° 29′ 39″.60	+3.″887	+0.″436

Following is the mean of two observations in declination made with the 5-inch Alt-Azimuth by Mr. G. A. HILL, on June 9 and 11:

$$\delta\,(1918.0) = +0°\ 29'\ 30''.05$$

NOTE.

In the article by S. W. BURNHAM in No. 738, entitled, "Measures of Double Stars," the introductory note, by an oversight, failed to state that all of the observations were made with the forty-inch telescope of the Yerkes Observatory.

CONTENTS.

ON THE APPARENT APSIDES OF A SATELLITE, W. AUHAGEN.
OCCULTATIONS BY THE *Moon*, BY A. HALL, H. E. BURTON, AND E. C. BOWER.
OBSERVATIONS OF *Nova Aquilæ* NO. 3, BY H. E. BURTON AND G. A. HILL.
NOTE

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POSITIONS OF THE STARS IN A CLUSTER WHOSE CENTER IS AT R.A. $18^h 34^m$ AND DECL. 5° 17′ DETERMINED FROM PHOTOGRAPHIC PLATES.

By RUTH D. BANNISTER.

The cluster of stars known as *N. G. C.* 6633 is closely followed by a similar group lying about one degree nearer the equator. This latter is not included among the clusters of Dryer's *New General Catalogue*. In the summer of 1915 several photographs were made of this region with the eighteen and one-half inch refractor of the Dearborn Observatory. These plates have been measured and the right ascensions and declinations of one hundred and seventy-five of the stars have been computed by referring them to the central star on the plate, *A. G.* Leip. II, 8697.

The record of the photographs is as follows:

Plate No.	Date 1915	Exposure	Hour Angle of Middle of Exposure	Observer	Quality of Images
1397	June 15	60^m and 70^m	1^h 44^m E.	Brown	Poor and Fair
1446	June 30	30^m	0 10 W.	Fox	Very good
1457	July 2	30	0 8 W.	Fox	Good
1472	July 11	30	0 3 E.	Brown	Very good

For the measurement of these plates a machine made by Wm. Gaertner & Co., of Chicago, was used. In this machine two screws at right angles to each other move the plate on its carriage under a fixed microscope. The screws are of half-millimeter pitch. Both screws were used, and after each plate was measured it was rotated through 180° and again measured in both coördinates.

As the central star was used for reference many more settings were made on it than on the other star images. The mean reading obtained for the central star was subtracted from the reading for each of the others to obtain their coördinates referred to the central star as origin. For the direct measures this gave stars with greater right ascensions and declinations than the central star positive coördinates. The signs of the measures made after reversing the plate were of course changed and the mean of the direct and reverse measures was taken as the *X* and *Y* for each star.

Three of the plates, 1446, 1457, and 1472 were measured in this way and the results reduced by the method of Professor Turner (*Monthly Notices of the Royal Astronomical Society*, V. LIV, p. 17, 1893). Three of the fourteen *A. G.* stars which appear in the field were not used in making the final solution for plate constants since the residuals they gave were so large as compared with those of the others that it seemed reasonable to suspect them of proper-motion or error in their catalogue positions. These were the stars *A. G.* 8695, 8696, and 8713. The mean of the standard rectangular coördinates thus obtained for each star from each of the three plates was found and the residuals computed. These residuals average $0^s.004$ in R. A. and $0''.06$ in Decl. Reduction of the positions to Right Ascension and Declination followed and these positions were brought to the date 1925.0.

The images of the best of the two longer exposures on plate 1397 were measured for diameter to give some indication of the relative magnitudes.

No other positions for the stars of this cluster were accessible for comparison.

FINAL CATALOGUE

Star	R. A. 1925.0 h m s	Decl. 1925.0 ° ′ ″	Diameter	*A. G. Leip. II*	*B. D.* + 5°
1	18 32 50.499	+5 33 54.49	0.098	....	....
2	32 51.720	8 56.41	.200	8663	3818
3	32 54.403	27 32.62	.144	....	....
4	32 54.485	29 5.50	.169	....	3819
5	32 56.225	4 23.58	.186	8664	3820
6	32 59.684	18 25.84	.071	....	....
7	32 59.658	30 50.09	.050	....	....
8	33 1.267	16 14.08	.057	....	....
9	33 3.024	24 45.08	.064	....	....
10	33 5.768	8 38.24	.092	....	3822
11	33 5.841	15 37.66	.057	....	....
12	33 10.043	14 10.44	.095	....	3823
13	33 12.398	31 51.01	.174	....	3825
14	33 16.832	12 6.85	.078	....	....
15	33 18.274	10 5.99	.064	....	....
16	33 21.410	29 17.06	.058	....	....
17	33 22.938	31 32.11	.104	....	....
18	33 23.825	13 41.71	.175	....	3829
19	33 24.464	31 13.66	.075	....	....
20	33 24.679	10 19.09	.048	....	....
21	33 24.714	2 44.72	.041	....	....
22	33 24.803	6 43.39	.111	....	....
23	33 26.344	13 38.68	.056	....	....
24	33 26.491	10 42.09	.090	....	....
25	33 26.505	23 8.65	.062	....	....
26	33 26.764	3 5.94	.049	....	....
27	33 29.213	12 37.75	.111	....	....
28	33 34.374	15 13.19	.195	8672	3830
29	33 34.649	12 58.38	.075	....	....
30	33 35.617	21 52.53	.063	....	....
31	33 35.879	23 7.64	.070	....	....
32	33 37.646	2 35.55	.115	....	....
33	33 37.884	4 51.53	.107	....	....
34	33 37.808	33 6.59	.083	....	....
35	33 39.307	6 31.74	.047	....	....
36	33 40.081	30 50.87	.155	....	3832
37	33 40.561	24 24.11	.060	....	....
38	33 40.910	26 35.04	.054	....	....
39	33 41.626	24 29.20	.135	....	....
40	33 42.624	4 13.22	.085	....	....
41	33 47.321	18 52.79	.081	....	....
42	33 47.532	27 38.53	.067	....	....
43	33 47.701	16 48.86	.070	....	....
44	33 48.759	8 23.52	.166	....	3835
45	33 50.805	4 17.34	.156	....	3836
46	33 50.937	13 29.81	.190	8679	3837
47	33 53.125	24 39.87	.187	....	3839
48	33 54.380	11 44.88	.235	8683	3840
49	33 54.682	10 22.33	.070	....	....
50	33 55.039	5 1.58	.132	....	3842

Star	R. A. 1925.0	Decl. 1925.0	Diameter	*A. G. Leip. II*	*B. D. + 5°*
	h m s	° ′ ″			
51	18 33 56.096	+5 5 13.36	.058	....	....
52	33 56.677	27 6.73	.048	....	....
53	33 57.048	9 55.46	.071	....	....
54	33 57.454	18 26.72	.141	....	....
55	33 58.336	7 12.41	.070	....	....
56	33 58.270	28 0.51	.199	8686	3843
57	33 59.323	25 50.39	.165	....	3844
58	33 59.941	15 17.40	.107	....	....
59	33 59.931	17 31.57	.064	....	....
60	34 4.534	5 30.06	.094	....	....
61	34 5.278	28 10.72	.093	....	....
62	34 6.851	14 11.88	.090	....	....
63	34 7.281	15 39.19	.156	....	3845
64	34 8.701	26 16.76	.159	....	3847
65	34 9.003	14 42.39	.083	....	....
66	34 10.276	12 15.15	.078	....	....
67	34 11.449	22 59.36	.124	....	....
68	34 11.906	10 46.16	.086	....	....
69	34 12.405	31 24.03	.055	....	....
70	34 12.550	12 14.63	.063	....	....
71	34 16.651	34 27.18	.156	....	....
72	34 17.987	10 12.73	.159	....	3848
73	34 19.639	31 22.78	.169	....	3849
74	34 20.822	31 15.90	.050	....	....
75	34 21.556	19 2.01	.059	....	....
76	34 21.545	34 12.83	.111	....	....
77	34 23.954	20 37.27	.193	8693	3850
78	34 25.288	15 53.91	.140	....	....
79	34 25.559	6 47.30	.118	....	....
80	34 27.118	27 54.19	.143	8695	3851
81	34 27.457	16 58.84	.176	8696	3852
82	34 27.791	23 50.92	.141	....	....
83	34 27.916	17 54.57	.197	8697	3853
84	34 28.561	2 20.30	.037	....	....
85	34 28.579	32 13.18	.050	....	....
86	34 28.748	24 58.65	.065	....	....
87	34 30.012	9 49.12	.142	....	....
88	34 30.767	12 2.34	.075	....	....
89	34 31.706	17 38.42	.159	....	3854
90	34 31.742	17 51.11	.049	....	....
91	34 32.402	4 12.44	.038	....	....
92	34 32.676	28 34.69	.078	....	....
93	34 35.024	17 41.26	.052	....	....
94	34 36.748	34 18.55	.185	....	3857
95	34 37.490	5 2.61	.047	....	....
96	34 37.496	4 17.49	.037	....	....
97	34 38.215	18 49.57	.057	....	....
98	34 38.651	26 5.54	0.063	....	....
99	34 39.067	21 26.34	.055	....	....
100	34 39.591	22 4.16	.191	8703	3858

Star	R. A. 1915.0	Decl. 1925.0	Diameter	*A. G. Leipzig II*	*B. D. + 5°*
	h m s	° ′ ″			
101	18 34 40.997	+5 1 30.75	.041	....	....
102	34 41.292	30 31.07	.143	....	3859
103	34 44.056	32 24.89	.058	....	....
104	34 44.514	4 53.71	.047	....	....
105	34 44.946	5 52.26	.150	....	3860
106	34 46.246	32 3.72	.070	....	....
107	34 49.509	13 33.42	.063	....	....
108	34 50.311	31 0.56	.067	....	....
109	34 51.152	25 25.55	.050	....	....
110	34 53.012	23 38.99	.048	....	....
111	34 54.186	24 36.35	.129	....	....
112	34 54.472	7 6.58	.062	....	....
113	34 54.950	30 48.51	.167	....	3863
114	34 55.248	25 49.21	.098	....	....
115	34 56.435	23 55.38	.217	8706	3864
116	34 57.436	22 11.50	.059	....	....
117	34 57.852	13 6.02	.138	....	....
118	34 58.091	18 24.15	.060	....	....
119	34 58.582	22 47.24	.057	....	....
120	34 58.796	24 12.04	.105	....	....
121	34 58.984	11 43.70	.078	....	....
122	34 58.957	29 50.00	.062	....	....
123	34 59.953	19 6.09	.046	....	....
124	35 0.453	29 45.07	.117	....	....
125	35 1.590	21 48.42	.112	....	....
126	35 1.935	28 43.71	.069	....	....
127	35 2.288	10 20.13	.181	....	3868
128	35 2.337	13 55.95	.181	....	3869
129	35 2.444	5 30.64	.048	....	....
130	35 2.502	18 56.60	.095	....	....
131	35 2.966	21 17.25	.057	....	....
132	35 3.386	22 40.68	.175	....	3870
133	35 3.840	16 3.54	.168	....	3871
134	35 6.869	28 28.22	.081	....	....
135	35 7.278	32 8.94	.065	....	....
136	35 7.628	16 54.13	.095	....	....
137	35 8.359	29 16.84	139	....	3872
138	35 10.158	27 50.91	.130	....	....
139	35 11.587	16 15.43	.198	....	3873
140	35 12.641	26 14.70	.056	....	....
141	35 13.028	22 37.60	.091	....	
142	35 13.492	24 25.95	.050	....	....
143	35 14.677	15 45.61	.099		....
144	35 16.360	7 11.59	.056		....
145	35 17.527	25 33.47	.141	....	3875
146	35 18.807	22 51.34	.072	....	
147	35 18.949	22 57.15	.084	....	....
148	35 19.198	25 10.94	.153	....	....
149	35 20.983	28 6.79	.183	....	3877
150	35 21.501	7 32.56	.056	....	....

Star	R. A. 1925.0	Decl. 1925.0	Diameter	*A. G. Leipzig II*	*B. D.* + 5°
	h m s	° ′ ″			
151	18 35 22.312	+5 23 28.12	.210	8712	3878
152	35 22.664	31 17.47	.200	8713	3879
153	35 24.890	11 0.61	.043	....	....
154	35 25.092	6 8.77	.119	....	3880
155	35 25.882	9 44.68	.041	....	....
156	35 26.454	7 58.65	.095	....	....
157	35 27.793	14 59.83	.047	....	....
158	35 32.169	1 52.34	.060	....	....
159	35 33.547	18 54.22	.054	....	....
160	35 33.850	26 9.95	.083	....	....
161	35 35.596	21 13.52	.056	....	....
162	35 36.652	13 35.26	.106	....	....
163	35 37.334	19 19.95	.143	....	....
164	35 37.396	20 36.66	.072	....	....
165	35 38.968	26 6.60	.168	....	...
166	35 41.088	26 19.50	.165	....	3885
167	35 43.285	19 53.23	.150	....	....
168	35 44.910	15 47.14	.154	....	3886
169	35 45.287	17 27.27	.177	....	3888
170	35 48.839	1 49.86	.104	....	....
171	35 49.589	25 0.60	.180	....	3889
172	35 50.049	27 22.91	.154	....	3890
173	35 54.338	20 1.58	.049	....	....
174	35 54.473	17 16.53	.069	....	....
175	35 55.383	11 45.38	.324	8719	3891

Dearborn Observatory, August 29, 1917.

THE ORBITAL MOTION OF THE DOUBLE STAR *HOUGH* 581.

BY G. VAN BIESBROECK.

Among the double stars whose motion I try to follow regularly, the binary HOUGH 581, which is No. 9739 of BURNHAM'S *General Catalogue*, has attracted my attention recently. So far as I know, no elements of the motion have been published for that star. Yet I believe it is fairly well established now, that its period is less than twenty-five years and that it has nearly completed one revolution since the discovery by HOUGH in 1895 at Evanston (*A. N.* 3557).

Its position for 1900.0 is:

$$19^{h}\ 51^{m}\ 36^{s} \qquad +41^{\circ}\ 35'.8$$

as deduced from *A. G. Bonn* 13537. By comparing with a position by BESSEL in 1825 (W_2 19^{h} 1646) the star appears to have a proper-motion of about $0''.3$ per year towards the north.

Its total magnitude is given as $7^{M}.56$ in *PD* 11104, where the color is called *GW*, yellowish-white. *Harvard Annals*, Vol. XLV, gives $7^{M}.36$, which corresponds to $7^{M}.64$ in the Potsdam system. The mean would be $7^{M}.6$.

HOUGH called the two stars equal and $7^{M}.5$. This would make the total magnitude too bright. Also DOOLITTLE could not detect a difference in the magnitudes of the two components. They both used instruments of 18 inches aperture. In his measures with the 36-inch refractor of the Lick Observatory AITKEN gives the magnitudes as $8^{M}.0$ and $8^{M}.7$. My estimates with the 40-inch here would make the difference a little less, about $0^{M}.5$ as a mean. That would make the two components

$$8^{M}.1 \text{ and } 8^{M}.6$$

There can be no doubt about the correct quadrant at the present time. The distance is a little over $0''.3$, which makes it a very easy pair under good conditions. When the star is as close as $0''.15$ or less, as it was measured in 1912 by Aitken, the difference in magnitude is somewhat too small for establishing the quadrant with certainty. Therefore it cannot be considered as violating the measures, if we reverse the quadrant in some of them in the investigation of the orbit. This was based on the following measures:

Nr.	Date	Angle	Distance	n	O − C $\Delta\theta$	O − C $\Delta\rho$	Observer
		°	″		°	″	
1	1895.688	258.4	0.32	2	0.0	−0.01	Hough
2	1905.701	149.9	.28	5	−1.1	− .02	Doolittle
3	1906.673	158.9	.26	3	−0.9	− .03	Doolittle
4	1906.753	342.3	.25	2	+1.8	− .04	Aitken
5	1911.511	102.6	.16	1	−0.1	+ .05	Aitken
6	1911.775	122.1	.28	1	+0.6	+ .17	Bryant
7	1912.657	166.5	.15	2	0.0	.00	Aitken
8	1917.605	57.2	.28	4	−1.5	− 02	V. B.
9	1918.404	66.2	.32	6	+1.2	+ 01	V. B.

[Hough—*A. N.* 3557. Doolittle—*Publ. Univ. Pennsylvania*, Vol. III, Part III, p. 111. Aitken—*Publ. Lick Obs.*, Vol. XII, p. 143. Bryant—*M. N.* Vol. 73, p. 112. V. B.—*Unpublished measures* with the 40-inch.]

Aside from this scanty material, there are a few more negative than positive indications by myself, published in *Ann. Observ. Royal de Belgique*, Vol. XIII, p. 380. These prove only that the star was below the limit of the 15-inch refractor used there, and they could not compete with the results obtained with larger telescopes; I therefore disregarded them altogether.

A glance at the measures as they stand makes the motion puzzling. But the annual areal velocity could be found roughly from the measures in 1905-06, 1911-12 and 1917-18. From these three fragments of the orbit the intermediate elliptic sectors could be inferred, until finally the whole orbit was built up. This showed that some of the position-angles had to be reversed so as to make them all consistent. Only the angles Nos. 2, 3, 8 and 9 were left unchanged. The five others were changed by 180° so as to place the companion in the correct quadrant at the present time. The provisional elements were then computed from five angles; *viz.* No. 1, mean of Nos. 3 and 4, No. 5, No. 7 and mean of Nos. 8 and 9, and the two distances No. 7 and mean of Nos. 8 and 9. The result was as follows:

Provisional Elements of Hough 581

$T = 1911.528$
$P = 24.445$ years ($n = +14^\circ.737$)
$e = 0.528$
$\Omega = 12^\circ.8$
$i = 39.2$
$\omega = 270.9$
$a = 0''.286$ (Hypothetical parallax $0''.024$)

The representation is shown in the list of observations. It is seen at once that the elements represent the angles very well. Perhaps the representation of the distances could be somewhat improved upon, but these are so discordant that it was thought better to depend more on the position-angles and wait until further observations would make it possible to improve the elements. Herewith is an ephemeris showing the character of the motion for the next ten years. If it proves essentially correct the star will be relatively easy to follow during that time. It is hoped that this interesting system will be less neglected than has been the case so far.

Ephemeris for Hough 581

	θ	ρ
	°	″
1918.0	61.9	0.310
19.	69.9	.320
20.	77.4	.327
21.	84.7	.333
22.	91.8	.336
23.	98.8	.338
24.	105.7	.339
25.	112.6	.338
26.	119.5	.336
27.	126.7	.332
1928.0	134.1	0.326

Yerkes Observatory, July 30, 1918.

SUNSPOT OBSERVATIONS,

MADE AT BERWYN, PENN., WITH A 4½-INCH REFRACTOR,

By A. W. QUIMBY.

1918	Time	New Grs.	Total		Fac. Grs.	Def.
			Grs.	Spots		
Jan. 1	9	1	6	10	2	poor
2	3	–	4	6	2	poor
3	9	–	4	5	2	poor
4	9	–	4	5	2	poor
5	9	2	5	8	2	fair
6	9	–	3	8	2	fair
8	8	1	3	26	3	fair
9	8	–	3	16	2	poor
10	8	–	3	16	–	poor
11	8	1	4	32	1	fair
12	3	–	3	36	1	fair
13	8	1	4	33	2	fair
14	8	1	4	17	2	poor
15	11	2	6	35	3	poor
16	9	–	5	56	3	fair
17	8	2	7	51	2	fair
18	8	–	4	23	–	poor
19	8	–	4	46	3	fair
20	8	1	5	23	2	poor
21	10	–	5	36	2	poor
22	2	1	5	31	1	poor
23	2	2	7	47	2	fair
24	9	–	5	23	3	poor
25	8	–	4	17	1	poor
26	9	1	5	14	1	poor
29	10	1	5	28	2	poor
30	3	1	5	13	2	poor
Feb. 1	3	–	3	4	2	poor
2	9	1	4	5	2	poor
4	8	–	3	6	2	fair
5	8	–	3	6	–	poor
6	9	–	2	4	1	fair
7	8	1	3	4	2	fair
8	4	–	3	5	2	fair
9	3	–	2	4	2	fair
10	9	–	1	2	–	v. p.
11	8	3	5	16	2	fair
12	12	1	6	33	3	fair
13	8	2	7	40	2	fair
14	8	–	5	40	2	fair
15	8	–	5	33	2	fair
16	9	–	2	12	–	poor
17	9	–	5	48	2	fair
18	8	1	5	44	2	fair
20	8	–	4	24	2	fair
21	8	1	5	24	2	fair
Feb. 23	9	2	4	9	3	fair
24	8	–	3	9	2	fair
25	8	2	5	12	2	fair
26	8	3	7	14	3	fair
27	8	–	4	5	3	fair
28	8	–	4	6	2	poor
Mar. 1	8	–	4	9	2	fair
2	8	–	3	6	2	fair
3	8	–	3	3	3	fair
4	8	–	3	4	3	fair
5	8	–	2	3	1	fair
6	9	–	2	2	1	poor
7	3	1	4	5	2	fair
8	8	1	5	8	3	fair
9	10	–	1	3	1	poor
10	8	–	5	8	4	fair
11	8	–	2	8	–	poor
12	8	–	1	3	–	poor
13	8	–	2	20	–	poor
15	7	2	4	46	3	fair
16	5	2	6	43	2	fair
17	7	1	6	42	2	fair
18	7	–	5	38	2	fair
19	7	–	5	32	2	fair
20	7	2	6	20	3	fair
21	7	–	2	10	2	poor
22	5	1	4	15	2	fair
23	5	2	5	24	2	fair
24	7	–	4	15	2	fair
25	5	1	4	32	3	fair
26	5	–	4	21	–	fair
27	7	–	4	12	–	poor
28	7	–	4	8	–	poor
29	5	2	5	12	2	fair
30	7	–	5	8	1	fair
31	7	1	6	18	2	fair
Apr. 1	7	1	5	22	2	fair
2	7	–	5	32	2	fair
4	5	1	5	66	2	good
5	7	1	5	63	2	good
6	7	2	7	54	3	good
7	5	1	7	10	2	fair
8	12	1	8	23	3	fair
13	12	–	5	28	–	poor
14	5	1	6	31	2	fair
15	7	1	7	30	3	fair
Apr. 16	7	–	6	17	3	fair
17	7	–	5	26	2	fair
18	12	–	3	13	2	poor
19	7	2	5	21	2	poor
20	12	–	3	17	2	fair
22	7	2	5	12	2	fair
23	7	–	5	10	3	fair
24	7	–	5	10	3	fair
25	5	–	4	10	2	fair
26	7	2	5	12	2	fair
27	4	–	5	21	2	fair
28	7	–	5	18	2	fair
29	11	–	5	17	2	fair
30	7	–	5	22	2	fair
May 1	7	2	7	30	3	fair
2	7	2	9	50	4	good
3	7	1	8	40	4	fair
4	7	1	8	30	3	fair
5	7	2	10	31	4	fair
6	7	–	8	31	3	fair
7	7	1	8	21	4	fair
8	5	2	9	36	3	fair
9	7	–	8	36	3	fair
10	7	1	8	21	3	fair
11	7	–	6	15	2	fair
12	5	–	6	21	2	fair
13	7	–	5	26	2	fair
14	5	–	4	24	1	fair
15	7	1	5	17	3	fair
16	4	–	4	16	3	fair
17	5	–	2	12	5	fair
18	7	–	2	11	2	fair
19	7	–	2	8	2	fair
20	10	1	3	8	2	fair
21	7	–	2	8	2	fair
22	7	–	2	8	2	fair
23	6	1	3	8	1	fair
24	7	–	2	8	2	fair
25	5	2	4	17	4	good
26	9	–	3	24	2	fair
27	3	–	1	31	3	fair
28	7	–	2	31	2	fair
29	7	1	3	40	3	fair
30	2	4	7	66	3	fair
June 1	7	4	11	80	3	fair
2	7	–	10	96	4	fair

SUNSPOT OBSERVATIONS *(Continued.)*

1918	Time	New Grs.	Total Grs.	Total Spots	Fac. Grs.	Def.	1918	Time	New Grs.	Total Grs.	Total Spots	Fac. Grs.	Def.	1918	Time	New Grs.	Total Grs.	Total Spots	Fac. Grs.	Def.
June 3	7	–	8	60	3	fair	June 13	11	1	2	7	2	fair	June 23	8	–	3	10	1	fair
4	7	–	8	71	3	fair	14	12	–	1	1	1	fair	24	1	–	3	22	4	fair
5	7	–	8	57	3	fair	15	7	–	1	1	1	fair	25	9	–	2	12	1	poor
6	7	–	4	31	2	poor	16	7	–	1	1	2	fair	26	6	2	2	2	2	poor
7	6	1	5	27	3	fair	17	7	–	1	1	2	fair	27	6	1	3	5	3	fair
8	7	–	4	14	3	fair	18	9	–	1	2	2	fair	28	7	2	5	12	5	fair
9	7	–	3	8	3	fair	19	7	3	4	14	2	fair	29	6	–	5	16	2	fair
10	7	–	2	8	2	fair	20	6	–	4	20	3	fair	30	7	–	5	12	2	fair
11	2	–	2	7	1	fair	21	7	–	4	18	2	fair							
12	11	–	1	4	1	fair	22	7	1	5	14	2	fair							

NOTE REGARDING AN ASTEROID FOUND AT THE LICK OBSERVATORY.

By H. M. JEFFERS.

An unknown asteroid was found on two plates taken with the Crossley Reflector on Dec. 3 and 10, 1917. The plates were exposed by Dr. Curtis and Miss Young, to obtain positions of *Erida* (718). On both plates there are two trails, but in each case one of them is undoubtedly that of (718). The trail of the other asteroid is near the edge of the field, and is slightly fainter than that of (718). I have deduced accurate positions for this asteroid, as follows:

Gr. M. T.	α 1917.0	δ 1917.0
1917 Dec. 3.7014	$2^h\ 24^m\ 55^s.6$	$+15°\ 28'\ 35''$
Dec. 10.6632	2 21 20 .1	+15 25 19

There is a remote possibility that these may not be positions of the same asteroid. The circular elements from the above positions are:

$$\begin{array}{rcl} \text{Epoch} & = & \text{1917 Dec. 9.5 Gr. M. T.} \\ u & = & 7°\ 46'.2 \\ \Omega & = & 44\ \ 31\ .8 \\ i & = & 6\ \ \ 8\ .3 \\ \mu & = & 862''.3 \\ \log a & = & 0.4096 \end{array} \quad \left.\begin{array}{l} \\ \\ \\ \\ \end{array}\right\} 1917.0$$

EPHEMERIS (1917.0)

1917	α	δ
Nov. 7.5	$2^h\ 47^m.7$	$+16°\ 11'$
15.5	39 .7	15 55
Nov. 23.5	32 .4	41
Dec. 1.5	26 .3	31
9.5	21 .8	26
Dec. 17.5	2 19 .2	+15 27

Magnitude = 14

The ephemeris from the circular elements is added in order to assist in the search for positions of the asteroid upon plates taken near opposition.

I did not identify it with any of the previously known minor planets. It is probably to be regarded as lost, for the present at least, unless through the finding of another position it becomes possible to determine elliptical elements.

Berkeley Astronomical Department, July 14, 1918.

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THE PERTURBATIONS CAUSED BY A CLOSE APPROACH OF TWO ASTEROIDS.

By W. L. Crum.

The present paper is an investigation of the effect of one small planet upon the motion of a second. The problem at once reduces to a study of the perturbations during the period of close approach. The three main divisions of the paper treat in turn: the formal integration of the equations of variation, the geometrical representation of the approach positions, and the numerical calculation of a particular set of perturbations.

Further work is being done in applying the present theory to the problem of the perturbations in a swarm of small planets, but the inquiry has not been concluded and definite results are not ready for publication.

I

§1. *Preliminary Definitions.*

We shall study the perturbations of one small planet H by another J while the two are in a region of close approach, and we define the term "close approach" in the following way. Consider the orbit of H relative to J. Unless H penetrates a circle of radius d_1 about J, the perturbations will be negligible; but, if H crosses a smaller circle of radius d_2 about J, they will approximate to those of actual impact. We agree then that a close approach occurs if the orbit of H relative to J crosses the ring between the two circles. (See figure 1.)

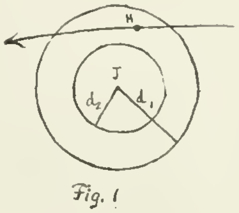

Fig. 1

Assume throughout that J, H and the *Sun* remain in one plane; that, therefore, the inclinations are zero and the node longitudes unnecessary. Represent the mass, eccentricity, mean motion, radius vector, semimajor axis, longitude, longitude of epoch, longitude of perihelion, and mean anomaly of H by the letters m, e, n, r, a, L, ϵ, ϖ and w respectively; and those of J by the corresponding letters primed.

Let μ be the mass of the *Sun*, and t the time. Let the subscript ν, $= 1$ or -1, denote values of the variables at the edges of the approach region. Set $T = nt$, for $T_{-1} \overline{<} T \overline{<} T_1$. The origin of time must be taken within the region; and the size of the region must be so fixed by choice of d_1 that T is small.

We shall in the main regard m as negligibly small, and take e' zero. Then J revolves undisturbed in a circle with n' constant, and ϖ' becomes unnecessary.

With these assumptions

$$r' = a', \quad L' = \frac{n'}{n} T + \epsilon', \quad w = T + \epsilon - \varpi$$

and, by the elliptic developments,

$$\frac{r}{a} = 1 - e \cos w + \frac{e^2}{2} (1 - \cos 2w) \tag{1}$$
$$+ \frac{3}{8} e^3 (\cos w - \cos 3w) + \frac{e^4}{3} (\cos 2w - \cos 4w) + \cdot \cdot$$

$$L = T + \epsilon + 2e \sin w + \frac{5}{4} e^2 \sin 2w \tag{2}$$
$$- \frac{e^3}{4}\left(\sin w - \frac{13}{3} \sin 3w\right) - \frac{e^4}{24}\left(11 \sin 2w - \frac{103}{4} \sin 4w\right) \cdots$$

Finally set

$$\bar{\rho} = \frac{r - r'}{a}, \quad \lambda = L - L',$$
$$S = \sin (\epsilon - \varpi), \quad C = \cos (\epsilon - \varpi)$$

§2. *The Disturbing Function.*

The principal part of the disturbing function is

$$R = \frac{m'}{d}, \qquad \text{where} \qquad d^2 = r^2 + r'^2 - 2rr' \cos\lambda\,.$$

Since $r - r'$ is nearly zero throughout — and in general actually becomes zero somewhere in — the region, the ordinary development of R in powers of $\frac{r}{r'}$, is here impossible.

Setting

$$x = r - r' \cos\lambda, \quad y = r' \sin\lambda$$

we have

$$d = \sqrt{x^2 + y^2} = x \sqrt{1 + \left(\frac{y}{x}\right)^2} = y \sqrt{1 + \left(\frac{x}{y}\right)^2};$$

and it appears that there are three cases to consider, according as $x <, =,$ or $> y$. But if these moving coördinate axes are rotated through an angle α, the new coördinates of J relative to H are:

$x' = x \cos\alpha + y \sin\alpha = r \cos\alpha - r' \cos(\lambda + \alpha),$

$y' = -x \sin\alpha + y \cos\alpha = -r \sin\alpha + r' \sin(\lambda + \alpha).$

With these

$$d = \sqrt{x'^2 + y'^2} = x' \sqrt{1 + \left(\frac{y'}{x'}\right)^2},$$

and α may always be chosen so that y'/x' is small. (See figure 2.)

If we make α variable in such a way that y'/x' is approximately zero, the rapidity of convergence becomes constant throughout the integration, and mechanical quadratures are unnecessary.

We therefore define α such that

$$y' = -r \sin\alpha + r' \sin(\lambda + \alpha) = 0,$$

and shall henceforth use this value entirely. It is the angle $J : H : Sun$ — in magnitude, the elongation of J from H.

Then d becomes x'. As we shall see, λ is very small in the region; and, setting

$$D = \frac{d}{a'}, \quad A = \frac{a}{a'}, \quad \rho = \frac{r - r'}{a'} = A\bar{\rho}\,,$$

we have the approximate relations:

$$\left.\begin{aligned} D &= \rho \cos\alpha + \lambda \sin\alpha\,, \\ \rho &= D \cos\alpha, \ \lambda = D \sin\alpha\,, \\ \tan\alpha &= \frac{r' \sin\lambda}{r - r' \cos\lambda}\,. \end{aligned}\right\} \tag{3}$$

The disturbing function reduces to

$$R = \frac{m'}{a'}\,\frac{1}{D}\,, \tag{4}$$

and it is D that we must expand. We shall expand in powers of e and T, retaining α as a variable parameter. Before doing this, it will be necessary to determine the order of T relative to e.

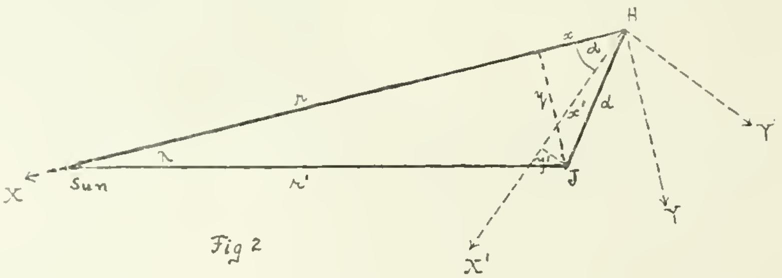

Fig 2

§3. *The Order of T.*

Since T is small, $\bar{\rho}$, λ may be expanded to

(5) $\bar{\rho} = \bar{\rho}_0 + \bar{\rho}'T + \cdots, \quad \lambda = \lambda_0 + \lambda'T + \cdots,$

where, from (1), (2),

(6)

$$\bar{\rho}_0 = \frac{a - r'}{a} - eC + e^2S^2 + e^3\frac{3}{2}CS^2 + e^4\frac{2}{3}C^2(1 - 4S^2) + \cdots,$$

(7) $\lambda_0 = \epsilon - \epsilon' + e_2S + e^2\frac{5}{2}CS + e^3\frac{1}{3}S(9 - 13S^2)$

$$+ e^4\frac{1}{24}CS(81 - 206\,S^2) + \cdots,$$

(8) $\bar{\rho}' = eS + e^2\,2CS + \cdots,$

$$\lambda' = 1 - \frac{n'}{n} + e\,2C + e^2\frac{5}{2}(C^2 - S^2) + \cdots. \tag{9a}$$

Let d_1 of §1 be chosen so that, for all T, $\bar{\rho}$ and λ are of order e^3 at least. Then, as T_0 is in the region, P and $\wedge$ defined by

$$P = \frac{a - r'}{a} - eC + e^2S^2, \quad \wedge = \epsilon - \epsilon' + e\,2S + e^2\frac{5}{2}CS \tag{10}$$

must be of order e^3 at least.

Using (10), and Kepler III, we have:

$$\frac{n'}{n} = A^{3/2} = 1 + e\frac{3}{2}C + e^2\left(\frac{15}{8}C^2 - \frac{3}{2}S^2\right) + \cdots,$$

and (9a) becomes

$$(9) \qquad \lambda' = e\frac{1}{2}C + e^2\left(\frac{13}{8}C^2 - 1\right) + \cdots .$$

Now since C and S cannot both be zero, either $\bar{\rho}'$ or λ' will be of order e. But, as $\bar{\rho}$ and λ are both of order e^3 for all T, both $\bar{\rho}'\,T$ and $\lambda'\,T$ are of order e^3. Therefore T is of order e^2 at least.

§4. *The Forms To Be Integrated.*

The equations of variation for the plane problem are

$$(11) \quad \begin{cases} \dot{a} = \dfrac{2a^2}{\mu}R_\varepsilon , \\[2ex] \dot{e} = \dfrac{a}{\mu e}(1 - e^2) \left\{ R_\varepsilon - \dfrac{1}{\sqrt{1 - e^2}}(R_\varepsilon + R_\varpi) \right\} \\[2ex] \dot{\varpi} = \dfrac{a}{\mu e}\sqrt{1 - e^2}\, R_e , \\[2ex] \dot{\epsilon} = -\dfrac{2a^2}{\mu}R_a + \dfrac{a}{\mu e}\sqrt{1 - e^2}\,(1 - \sqrt{1 - e^2})\, R_e , \end{cases}$$

where the dot means differentiation by T and the subscripts indicate partial differentiation.

Now the object of excluding the d_2 circle of §1 from the region was to prevent the variations in the elements from becoming large, and we may therefore integrate in the usual way: by regarding the elements constant in the right members. Then, if only the two lowest orders in the coefficients are kept, the variations are:

$$(12) \quad \begin{cases} \dfrac{\delta a}{a} = \dfrac{2a}{\mu}\displaystyle\int R_\varepsilon\, d\,T , \quad \delta e = -\dfrac{a}{\mu}\dfrac{1}{e} \quad R_\varpi\, d\,T , \\[2ex] e\,\delta\varpi = \dfrac{a}{\mu}\displaystyle\int R_e\, d\,T , \\[2ex] \delta\epsilon = -\dfrac{2a^2}{\mu} \quad R_a\, d\,T + \dfrac{a}{\mu}\dfrac{e}{2}\displaystyle\int R_e\, dT. \end{cases}$$

In getting the variations it will then be necessary to integrate the forms:

$$(13) \quad \Delta^z = \int R_z dT = -\frac{m'}{a'}\int\frac{D_z}{D^2}dT; \; z = a,\, e,\, \varpi,\, \epsilon.$$

§5. *Integration by Change of Variable.*

In order to evaluate $\int\frac{D_z}{D^2}dT$ it is convenient to change the independent variable from T to α. If we keep only the two lowest orders in e, we need not keep the T^2 terms in the expansions, and we have

$$(14) \qquad \rho = \rho_0 + \rho'\,T, \qquad \lambda = \lambda_0 + \lambda'\,T,$$

where ρ has been developed like $\bar{\rho}$. From these and (3_2)

$$\tan\alpha = \frac{\lambda}{\rho} = \frac{\lambda_0 + \lambda'\,T}{\rho_0 + \rho'\,T},$$

giving

$$dT = U\frac{\sec^2\alpha}{(\lambda' - \rho'\tan\alpha)^2}d\alpha ,$$

where

$$U = \rho_0\,\lambda' - \rho'\,\lambda_0 .$$

These, with (3) and (13) give

$$\begin{aligned} \Delta^z &= -\frac{m'}{a'}\frac{1}{U}\int(\rho_z\cos\alpha + \lambda_z\sin\alpha)\,d\alpha \\ &= -\frac{m'}{a'}\frac{1}{U}(\rho_z\sin\alpha - \lambda_z\cos\alpha). \qquad (15) \end{aligned}$$

§6. *The Integration Limits.*

The determination of the integration limits for α is of the first importance.

From (14),

$$D^2 = \rho^2 + \lambda^2 = \rho^2_0 + \lambda^2_0 + 2\,(\rho_0\,\rho' + \lambda_0\,\lambda')\,T + (\rho'^2 + \lambda'^2)\,T^2;$$

and, if the minimum value of D^2 and the corresponding values of the other quantities be indicated by the subscript m,

$$\left.\begin{aligned} &T_m = -\frac{\rho_0\rho' + \lambda_0\lambda'}{\rho'^2 + \lambda'^2},\; D_m{}^2 = \frac{U^2}{\rho'^2 + \lambda'^2}, \\ &\rho_m = \lambda'\frac{U}{\rho'^2 + \lambda'^2}, \tan\alpha_m = -\frac{\rho'}{\lambda'},\; \lambda_m = -\rho'\frac{U}{\rho'^2 + \lambda'^2}. \end{aligned}\right\} (16)$$

It is obvious from symmetry that the region must be chosen so that $D_1^2 = D^2_1$. Now D_1 is a given parameter, and determines the d_1 circle of §1. We can therefore express the end values of the various quantities in terms of D_1.

$$T_\nu = T_m + \nu\tau, \text{ where } \tau = +\frac{\sqrt{D_1^2\,(\rho'^2 + \lambda'^2) - U^2}}{\rho'^2 + \lambda'^2}$$

$$\rho_\nu = \rho_m + \nu\rho'\tau,\; \lambda_\nu = \lambda_m + \nu\lambda'\tau ,$$

$$\tan\alpha_\nu = \lambda_\nu/\rho_\nu = \tan\,(\alpha_m + \xi_\nu)$$

where, if k_ν is an integer,

$$\xi_\nu = k_\nu\,\pi + \nu\,\xi,\; \tan\xi = \frac{\tau(\rho'^2 + \lambda'^2)}{U},\; |\xi| < \frac{\pi}{2}.$$

If u be the sign of U,

$$\sin\xi = u\frac{\tau\overset{+}{\sqrt{\rho'^2 + \lambda'^2}}}{D_1} = u\overset{+}{\sqrt{1 - \left(\frac{D_m}{D_1}\right)^2}}. \qquad (17)$$

In order to find k_ν, let T_ρ and T_λ be the values of T for which ρ and λ respectively are zero. Then α must be $\frac{\pi}{2}$ or $\frac{3\pi}{2}$ at T_ρ and o or π at T_λ.

T_ρ and T_λ are uniquely determined by

$$T_\rho = -\frac{\rho_0}{\rho'}, \quad T = -\frac{\lambda_0}{\lambda'}.$$

and comparison of T_m, T_ρ and T_λ shows that T_m always lies between the others. Therefore we have the following limitation on α: the value of α cannot pass through both an odd and an even multiple of $\frac{\pi}{2}$ between α_m and either α_ν.

Using this and the facts that ξ has the sign of U and does not exceed $\frac{\pi}{2}$ numerically, we can show that k_ν must always be zero. Therefore

$$\alpha_\nu = \alpha_m + \nu\,\xi\,. \tag{18}$$

§7. *Evaluation of the Type Integral.*

Inserting these limits in our integrals, and using (17) with

$$\cos\alpha_m = \frac{\rho_m}{D_m}, \quad \sin\alpha_m = -\frac{\lambda_m}{D_m}$$

we get

$$\Big[\rho_z\sin\alpha - \lambda_z\cos\alpha\Big]_{\alpha_{-1}}^{\alpha_1} = \frac{2U}{D_m}\,\frac{\rho_z\lambda' - \lambda_z\rho'}{\rho'^2 + \lambda'^2}\sqrt{1 - \left(\frac{D_m}{D_1}\right)^2}\,.$$

Then, by (15), and expanding the radical,

(19)

$$\Delta^z = -\frac{m'}{a'}\,\frac{2u}{D_m}\,\frac{\rho_z\lambda' - \lambda_z\rho'}{\rho'^2 + \lambda'^2}\left\{1 - \frac{1}{2}\left(\frac{D_m}{D_1}\right)^2 + \cdots\right.$$

A consideration of this form shows that Δ^z can be infinite only if D_m is zero. But this possibility — the case of actual impact — was ruled out in §1. The magnitude of D_m depends upon that of U, and the order of this depends upon the choice of P, $\wedge$. This choice is therefore limited by the condition that D_m shall not be very small.

The only two conditions on D_1 are that it must be of order e^3, and that $D_1^2 > D_0^2$. We assume D_1 chosen so large relative to D_m that we may neglect

$$\tfrac{1}{2}\,(D_m/D_1)^2.$$

It is important to note that, with such a choice of D_1, the integration over the region of close approach — the region where T is of order e^2 — gives the entire perturbation, to our degree of approximation, for the whole revolution.

§8. *General Case for Both Orbits Elliptic.*

A study of the above analysis shows that it is independent of the fact that e' is zero except for the values of

$$\rho,\ \lambda,\ \rho_0,\ \lambda_0,\ \rho',\ \lambda',\ \epsilon - \epsilon',\ \frac{a - a'}{a'}\,.$$

We can therefore immediately generalize our results to the case where the orbits of both J and H are elliptic by finding expressions for these quantities.

Without writing out the various expressions, we observe that w', $\frac{r'}{a'}$, and L' must be of the same form as w, $\frac{r}{a}$ and L respectively. Furthermore, we must define S', C' similarly to S, C and take $\lambda = \frac{r'}{a'}(L - L')$.

With these definitions, we have as before

$$D = \rho\cos\alpha + \lambda\sin\alpha.$$

The expansions of ρ and λ are somewhat more complicated, and the new values of the arbitrary parameters P, $\wedge$ are given by

$$P = \frac{1}{a'}\left\{a - a' - (aeC - a'e'C') + (ae^2S^2 - a'e'^2S'^2).\right\}$$

$$\wedge = \epsilon - \epsilon' + (e2S - e'\,2S') + \left(e^2\,\frac{5}{2}\,CS - e'^2\,\frac{5}{2}\,C'S'\right).$$

With these and the resulting changes, the above results may be carried over at once to the general case.

II

§9. *The Location of the Approach.*

To apply the theory of Sections 1 to 7 to any particular pair of asteroids J, H, we must have $i = i' = e' = 0$ and m negligibly small. We must be given μ, m', e, ϖ and a, a' or n, n'. In order that there may be an approach of the kind we have treated, e must be small and $\frac{a - a'}{a}$ must be of order e.

Assuming that there is an approach, we must find the position of the approach region relative to one of the orbits — say that of H — and the positions of the two planets in the region at some definite time — say $T = 0$. It is then necessary to find $\epsilon - \varpi$ and $\epsilon - \epsilon'$, and these are given by (10).

Solving the first of these, and dropping the inadmissible value, we have approximately

$$C = \frac{1}{e}\left(\frac{a - r'}{a} + e^2 - P\right).$$

This determines S except for sign, and the second of the given relations shows that $\epsilon - \epsilon'$ and S have opposite signs.

It is clear then, that, if we are given $a - r'$ and the fact that there is an approach, $\epsilon - \epsilon'$ is determined except for sign. Its sign must be given, and determines that of S. Then $\epsilon - \varpi$ is completely determined. As they enter only in the third order terms in the determination of $\epsilon - \varpi$ and $\epsilon - \epsilon'$, P and Λ are arbitrary.

With $\epsilon - \varpi$ known, the close approach region may be located relative to the orbit of H. There are several ways of doing this, but a convenient approximate method is to determine the intersection of the orbits. Its position relative to the perihelion is

$$L_\rho - \varpi = T_\rho + \epsilon - \varpi + 2e \sin\,(T_\rho + \epsilon - \varpi) + \cdots .$$

If all the higher ordered terms are neglected, this is merely $\epsilon - \varpi$, and this value is sufficiently accurate for our purpose.

§10. *Sectors and Modes of Approach.*

In a study of the geometrical appearance of an approach, the main points to be observed are the values at T_m, and the relative positions of T_m, T_ρ, T_λ. The answers to all these questions depend upon the signs of ρ', λ' and U.

Now by (8)

$$\rho' = A\, e\, S\,(1 + e2C + \cdots);$$

and ρ' is obviously zero only when $\epsilon - \varpi$ is o or π and is positive when $\epsilon - \varpi$ is between 0 and π, and negative when $\epsilon - \varpi$ is between π and 2π.

By (9)

$$\lambda' = e\frac{1}{2}C + e^2\left(\frac{13}{8}C^2 - 1\right) + \cdots ,$$

and λ' is zero when

$$C = -\frac{2}{13e}(1 \pm \sqrt{1 + 26\, e^2}) .$$

Now e cannot exceed 4/5 and the minus sign must be kept. Hence

$$C = 2e = \cos\,(\pm\varphi)\ ,\ \varphi < \frac{\pi}{2} .$$

When $|\epsilon - \varpi|$ is less than φ, λ' is positive, and *vice versa.*

Then the orbit of H may be divided into four sectors (see figure 3) according to the signs of ρ' and λ'. The signs of ρ', λ' are, for sector 1, + +; for 2, + − ; for 3, − − ; for 4, − +.

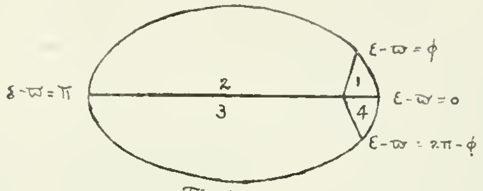

Fig. 3

The sign of U is arbitrary, for it depends through ρ_0 and λ_0, upon P and Λ. As we have seen, the selection of these is governed only by the fact that D_m must not be too small for our approximation methods.

Recalling the values of the quantities for D a minimum, we may exhibit the main facts in the following table.

Sector			1		2		3		4
$\epsilon - \varpi$	>		0		φ		π		$2\pi-\varphi$
	=	0		φ		π		$2\pi-\varphi$	
	<		φ		π		$2\pi-\varphi$		2π
ρ'		0	+	+	+	0	−	−	−
λ'		+	+	0	−	−	−	0	+
$\frac{1}{U}\rho_m$		+	+	0	−	−	−	0	+
$\frac{1}{U}\lambda_m$		0	−	−	−	0	+	+	+
$\tan\alpha_m$		0	−	∞	+	0	−	∞	+
$\frac{1}{U}(T_\rho - T_m)$		∞	−	0	+	∞	−	0	+
$\frac{1}{U}(T_\lambda - T_m)$		0	+	∞	−	0	+	∞	− .

From this table we can form a rough picture of the approach for any value of $\epsilon - \varpi$ and for either sign of U. It would also be useful to know whether T_ρ and T_λ actually lie within the region. This could be found by computation from the above formulas, or may be seen roughly from the zeros and infinities in the table.

Figure 4 gives the appearance of the approach in each of the eight typical positions when U is positive; and figure 5, when it is negative. The eccentricity of the H orbit is taken large for convenience, and only the arcs of the J orbits at the points of interest are drawn. The figures are not drawn even approximately to scale.

Many facts of interest appear from a study of these figures. It is clear that the signs of ρ_m and $T_\rho - T_m$ in the table are consistent. It is important to observe the bearing of the sign of U and the value of $\epsilon - \varpi$ upon the question whether H arrives at the intersection earlier or later than J.

We note also that the arrangements of J, H and T_ρ for $U > 0$, as we go from the first sector around the orbit in the direction of motion, are the same as those of J, H and T_ρ for $U < 0$, as we go from sector 4 in the opposite direction; the only important difference being in the sign of ρ_m.

Before leaving the geometrical study, we observe that it can be extended to the case for $e' \neq 0$. In addition to the data required above, we must be given e' and ϖ'. We may then determine the differences $\epsilon - \varpi$, $\epsilon - \epsilon'$, $\epsilon' - \varpi'$; and the location of the approach is then possible. A somewhat more complicated division into sectors and discussion of modes of approach may then be carried out.

III

§11. *Collection of Formulas.*

Choosing D as in §7 we have by (19)

$$\Delta^z = -\frac{m'}{a'}\frac{2}{U}\frac{\rho_z\lambda' - \lambda_z\rho'}{\sqrt{\rho'^2 + \lambda'^2}}.$$

Now, if

$$U = \rho_0\lambda' - \rho'\lambda_0 = A(\bar\rho_0\lambda' - \bar\rho'\lambda_0) = A\bar U,$$

$$\tan\beta = \frac{\rho'}{\lambda'} = A\frac{\bar\rho'}{\lambda'}, \quad |\beta| \overline{<} \frac{\pi}{2},$$

the integral is

$$\Delta^z = \frac{m'}{a'}\frac{2}{U}(\lambda_z\sin\beta - A\rho_z\cos\beta).$$

If only the two lowest orders are kept, the additional formulas needed are:

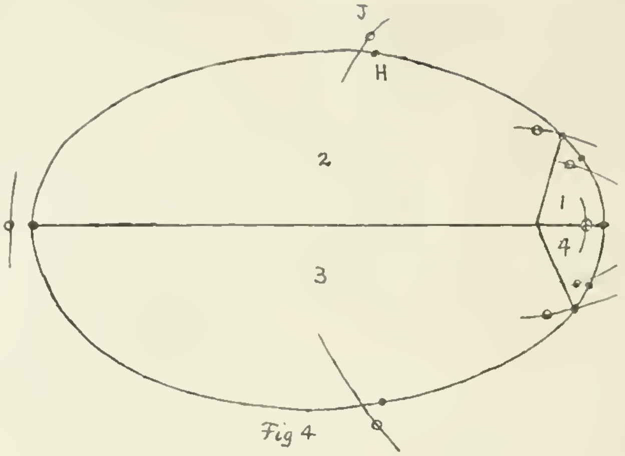

Fig 4

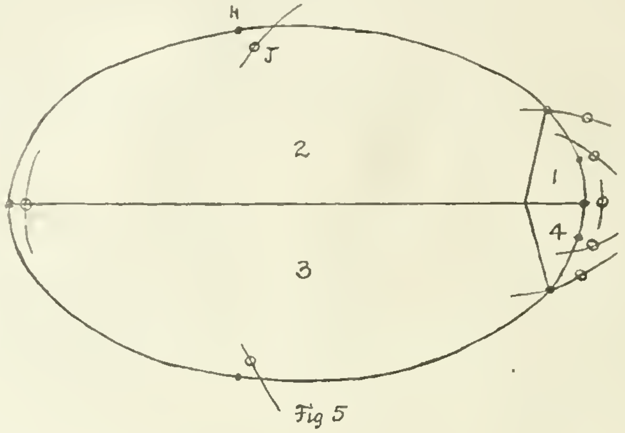

Fig 5

z	ρ_z	λ_z
ϵ	$eS(1+e2C)$	$1+e2C$
ϖ	$-eS(1+e2C)$	$-e^2\left[C + e\frac{5}{4}(2C^2-1)\right]$
e	$-C + e2(1-C^2)$	$2S\left(1+e\frac{5}{2}C\right)$
a	$\frac{1}{a}(1-eC)$	0;

$$\frac{\delta a}{a} = \frac{2a}{\mu}\Delta^\epsilon, \quad \delta e = -\frac{a}{\mu}\frac{1}{e}\Delta^{\varpi}, \quad e\delta\varpi = \frac{a}{\mu}\Delta^e,$$

$$\delta\epsilon = -\frac{2a^2}{\mu}\Delta^a + \frac{a}{\mu}\frac{e}{2}\Delta^e.$$

From these two sets we have

$$\frac{\delta a}{a} = h\,2\,(1+e\,2C)\,[\sin\beta - e\,SA\cos\beta],$$

$$\delta e = h\left[2C\left(1+e\frac{5}{4}\frac{2C^2-1}{C}\right)\sin\beta - S(1+e\,2C)A\cos\beta\right],$$

$$e\delta\varpi = h\left[2S\left(1+e\frac{5}{2}C\right)\sin\beta + C\left(1-e\,2\frac{1-C^2}{C}\right)A\cos\beta\right],$$

$$\delta\epsilon = h\left[eS\sin\beta + 2\left(1-e\frac{3}{4}C\right)A\cos\beta\right].$$

where

$$h = \frac{m'}{\mu}\frac{2}{U},\ A = 1 + eC.$$

We shall also need, to get β,

$$\bar{\rho}' = eS\,(1 + e2C),\ \lambda' = e\frac{C}{2}\left(1 + e\,\frac{13C^2 - 8}{4C}\right).$$

Everything in these formulas except h, which depends on U, is given. We shall compute the values of $2/h$ times each variation for eight typical values of $\epsilon - \varpi$ namely, $o,\ \frac{\pi}{4},\ \phi,\ 3\frac{\pi}{4},\ \pi,\ 5\frac{\pi}{4},\ 2\pi - \phi,\ 7\frac{\pi}{4}$ – about the orbit of H, and for six values namely, $o,\ \sin^{-1}\frac{3}{5},\ \frac{\pi}{4},\ \sin^{-1}\frac{4}{5}\ \phi,\ \pi$ – in the first quadrant.

In all this work we shall take $e = 0.1$, and have therefore

$$\phi = \cos^{-1}\frac{1}{5} \doteq 78°\ 30'.$$

The values obtained in this manner will be proportional to the numerical values of the variations if we assume that h, and therefore U and D_m, have the same values for every $\epsilon - \varpi$.

Since U depends, in addition to $\bar{\rho}'$, λ', upon $\bar{\rho}_0\ \lambda_0$, where

$$\bar{\rho}_0 = P + e^3\frac{3}{2}CS^2 + e^4\frac{2}{3}C^2(1 - 4S^2) + \cdots$$

$$\lambda_0 = \wedge + e^3\frac{1}{3}S(9 - 13S^2) + e^4\frac{1}{24}CS(81 - 206S^2) + \cdots$$

it is clear that D_m may be made invariant by proper choice of the arbitraries P, $\wedge$ as functions of $\epsilon - \varpi$. Furthermore, the sign of U may also be adjusted; for, to any value of $\bar{\rho}_0$, there is a corresponding value with opposite sign which may be got by choice of P.

The simplest way to find how U varies with $\epsilon - \varpi$ is to take both P, $\wedge$ as zero. Then

$$\bar{\rho}_0 = e^3\left[\frac{3}{2}CS^2 + e\,\frac{2}{3}C^2(1 - 4S^2)\right]$$

$$\lambda_0 = e^3\left[\frac{1}{3}S(9 - 13S^2) + e\frac{1}{24}CS(81 - 206S^2)\right]$$

§12. *Results of Computations.*

Using the formulas of the previous section and the value $e = 0.1$, we calculate the results in the following tables. The first table gives the values of the four variations each multiplied by $2/h$, and the values of U. The second table gives the true values of the variations for U positive, multiplied by $\frac{\mu}{m'}$.

$\epsilon - \varpi$	$\frac{\delta a}{a}$	δe	$e\delta\varpi$	$\delta\epsilon$	$\frac{1}{e^4}U$
0°	0	0	+2.2	+4.0	+ .04
45°	+4.1	+2.	+3.6	+1.6	− .27
78°	+4.2	+ .32	+4.3	+ .2	+1.4
135°	−3.	+1.8	−2.8	+2.	− .18
180°	0	0	−1.8	+3.9	− .03
225°	+3.	−1.8	−2.8	+2.	− .18
282°+	−4.2	− .32	+4.3	+ .2	+1.4
315°	−4.1	−2.	+3.6	+1.6	− .27
0°	0	0	+2.2	+4.	+ .04
26°+	+3.4	+2.2	+2.8	+2.6	− .43
45°	+4.1	+2.	+3.6	+1.6	− .27
53°+	+4.3	+1.7	+3.8	+1.2	−1.4
78°+	+4.2	+ .32	+4.3	+ .2	+1.4
90°	−3.9	+ .3	−4.	+ .2	+1.3

$\epsilon - \varpi$	$\frac{\delta a}{a}$	δe	$e\delta\varpi$	$\delta\epsilon$
0°	0	0	+55	+100
45°	+15	+ 7.4	+13	+ 6
78°+	+ 3	+ .23	+ 3	+ .14
135°	−17	+10	−16	+ 11.
180°	0	0	−60	+130
225°	+17	−10	−16	+ 11
282°+	− 3	− .23	+ 3	+ .14
315°	−15	− 7.4	+13	+6
0°	0	0	+55	+100
26°+	+ 8	+ 5.2	+ 6.6	+ 6.1
45°	+15	+ 7.4	+13	+ 6
53°+	+ 3.1	+ 1.2	+ 2.7	+ .87
78°+	+ 3	+ .23	+ 3	+ .14
90°	− 3	+ .23	− 3.1	+ .15

§13. *Discussion of the Tables.*

The values of U are interesting both in sign and in magnitude. It will be recalled from the geometrical discussion that the sign of U entered with the value of $\epsilon - \varpi$ into the determination of the mode of the approach. On the other hand, the magnitude of U governs to a large extent the effect of the approach. There is no great variation in magnitude, speaking in terms of orders of e; and we note that the smallest values are at 0 and π and the largest at $\pm\phi$. The irregularities in the sign and magnitude of U depend largely upon the choice of P, $\wedge$.

The values of the variations as given in the second table should be studied in connection with the geometrical properties studied above.

It appears that $\frac{\delta a}{a}$ is 0 or nearly 0 at the points of division between the sectors, and goes to a fairly large value in the middle of each sector. It is positive in sectors 1 and 3 and negative in 2 and 4.

Similar observations may be made on the magnitude of δe. Its sign is positive in 1 and 2, and negative in 3 and 4.

On the other hand $e\delta\varpi$ and $\delta\epsilon$ have their large values at perihelion and aphelion, and fall off at $\pm\varphi$. It is seen that $e\delta\varpi$ is positive at perihelion and negative at aphelion, while $\delta\epsilon$ is positive everywhere.

It appears that there is complete continuity in the values in the table, and they are also in accord with the conclusions drawn from the geometrical study. If the sign of U is changed the signs of all the variations are just reversed. If U is chosen constant by proper selection of P, $\wedge$, the variations have values proportional to those given in the first table. For comparing effects for different values of $\epsilon - \varpi$, these are the most useful results.

It remains to consider the value of the factor $\frac{m'}{\mu}\frac{1}{|D_m|}$. If the asteroid is assumed to have a radius less than one hundred miles and a mean density less than one-half that of the *Earth*, $\frac{m'}{\mu}$ will be of the order e'^{10} at least. If the ratio of r' to the mean radius of the *Earth's* orbit is not greater than 2, we can also show that

$$d_m = a'D_m = .19$$

millions of miles. It is obvious then that, for the region covered by our investigation, the nearest approach leaves the planets still far from actual impact.

In concluding we observe that the above calculations may be carried through for the general case of $e' \neq o$ by evaluating the more complicated forms of §8.

This completes the solution of the problem for the most general type of plane motion. The scope of the solution is limited only by the order of magnitude of D_m. While this can of course be taken much smaller than the order e^3 used above, a point will soon be reached where the variations are so large as to render the present method useless.

Yale University, 1917.

EPHEMERIS OF BORELLY'S COMET,

By FRANK E. SEAGRAVE.

The constants and ephemeris of BORELLY'S Comet have been computed from the following elements as copied from the August number of *The Observatory*. The comet is due to reach perihelion Nov. 16.65, 1918, G. M. T.

ELEMENTS.

T = Nov. 16.65, 1918, G.M.T.
$\omega = 352° 21'$
$\Omega = 76° 58'$
$\pi = 69° 19'$
$i = 30° 43'$
$e = 0.61530$
$\text{Log } a = 0.55980$
$\text{Log } q = 0.14500$
$\mu = 513''.22$

CONSTANTS.

$$x = r\,[9.93821] \sin [164° 55' 48'' + u]$$
$$y = r\,[9.95141] \sin [\ 91° 37' 40'' + u]$$
$$z = r\,[9.82573] \sin [\ 35° 23' 14'' + u]$$

Greenwich Midnight 1918	α h m s	δ ° ′ ″	Log r	Log Δ
Oct. 15	6 4 37	− 6 2 47	0.15934	9.89386
" 19	6 11 33	− 4 36 56	0.15608	9.87319
" 23	6 18 11	− 2 59 32	0.15320	9.85206
" 27	6 24 30	− 1 8 49	0.15072	9.83061
" 31	6 30 30	+ 0 57 31	0.14866	9.80905
Nov. 4	6 36 6	+ 3 22 13	0.14706	9.78763
" 8	6 41 17	+ 6 3 38	0.14588	9.76657
" 12	6 45 59	+ 9 6 52	0.14520	9.74651
" 16	6 50 19	+12 30 34	0.14492	9.72750
" 20	6 53 53	+16 16 15	0.14514	9.71082

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OBSERVATIONS DE COMÈTES ET DE PLANÈTES,

FAITES À L'OBSERVATOIRE DE BESANÇON
ÉQUATORIAL COUDÉ DE 0m 33 D'OUVERTURE
PAR M. P. CHOFARDET.

Comète 1913 *f* (Delavan)

Dates		T. m. Besançon	ΔA.R.	ΔD.P.	Cp.	A.R. app.	log f.p.	D.P. app.	log. f.p.	Réd. au j.		✻
1913-14		h m s	m s	′ ″		h m s		° ′ ″		s	″	
Déc.	19	6 49 4	+ 1 40.13	+ 4 15.9	12 , 9	3 1 50.17	9.369*n*	97 15 59.1	0.847*n*	+4.10	−19.1	1
	19	7 48 37	+ 1 38.13	+ 4 1.7	12 , 9	3 1 48.17	9.151*n*	97 15 44.9	0.853*n*	+4.10	−19.1	1
	20	6 24 56	+ 0 48.67	− 1 32.1	12 , 9	3 0 58.70	9.417*n*	97 10 11.2	0.844*n*	+4.09	−19.0	1
	20	7 25 29	+ 0 46.49	− 1 47.4	12 , 9	3 0 56.52	9.234*n*	97 9 55.9	0.850*n*	+4.09	−19.0	1
	23	6 15 42	+ 0 31.33	+ 1 59.7	12 , 9	2 58 26.27	9.405*n*	96 51 40.3	0.844*n*	+4.08	−18.9	2
Janv.	13	6 10 57	+ 0 47.57	+12 40.6	12 , 9	2 44 42.19	9.047*n*	94 11 15.0	0.837*n*	+0.86	− 3.0	3
	15	7 30 36	− 0 7.67	− 5 27.5	12 , 9	2 43 46.93	8.630	93 53 7.0	0.836*n*	+0.84	− 2.9	3
	16	6 18 39	− 2 1.17	− 9 33.2	12 , 16	2 43 22.95	8.889*n*	93 44 39.4	0.835*n*	+0.84	− 2.8	4
	19	6 18 58	− 4 49.55	− 3 42.9	9 , 12	2 42 13.63	8.722*n*	93 17 19.3	0.832*n*	+0.81	− 2.9	5
	20	6 25 6	− 1 22.79	+11 35.7	12 , 9	2 41 52.28	8.537*n*	93 8 4.4	0.831*n*	+0.78	− 2.9	6
	22	6 23 21	+ 2 5.57	− 4 27.7	9 , 12	2 41 14.23	8.347*n*	92 49 18.2	0.829*n*	+0.73	− 2.7	7
	23	6 25 16	+ 2 59.02	− 3 14.9	9 , 10	2 40 56.35	8.050*n*	92 39 52.4	0.828*n*	+0.71	− 2.6	8
	24	6 50 37	+ 0 21.01	+10 41.3	14 , 9	2 40 40.19	8.599*n*	92 30 9.2	0.827*n*	+0.71	− 2.8	9
	26	6 23 22	− 0 8.07	− 8 20.1	12 , 9	2 40 11.08	7.832	92 11 8.0	0.823*n*	+0.68	− 2.6	9
	30	6 58 18	+ 0 29.86	+ 1 41.7	12 , 9	2 39 25.27	8.982	91 31 40.7	0.821*n*	+0.62	− 2.7	10
	31	6 47 33	− 0 53.19	− 2 57.3	12 , 9	2 39 16.74	8.928	91 21 47.4	0.820*n*	+0.61	− 2.7	11
Fév.	2	6 41 27	+ 1 19.83	+ 3 23.3	12 , 9	2 39 2.70	8.939	91 1 47.0	0.818*n*	+0.57	− 2.7	12
	3	6 24 47	+ 1 14.60	− 6 35.5	12 , 9	2 38 57.46	8.821	90 51 48.2	0.817*n*	+0.56	− 2.7	12
	5	6 51 18	+ 1 52.18	+ 3 43.2	12 , 9	2 38 49.91	9.097	90 31 20.8	0.814*n*	+0.52	− 2.7	13
	6	6 43 19	− 1 45.21	− 0 47.9	9 , 12	2 38 47.69	9.073	90 21 7.6	0.813*n*	+0.53	− 2.8	14
	8	6 45 10	− 1 20.92	+ 1 16.8	12 , 9	2 38 46.35	9.128	90 0 34.7	0.811*n*	+0.50	− 2.8	15
	12	6 41 57	+ 2 22.49	− 7 12.9	9 , 12	2 38 55.98	9.190	89 18 59.5	0.806*n*	+0.42	− 2.8	16
	13	6 47 19	+ 2 45.07	− 2 4.9	9 , 12	2 39 0.60	9.229	89 8 32.8	0.805*n*	+0.40	− 2.9	17
	20	7 15 59	+ 2 10.81	+ 2 18.1	9 , 12	2 40 2.95	9.401	87 53 50.6	0.798*n*	+0.31	− 3.1	18
Mars	11	7 19 40	− 0 23.95	− 5 10.4	12 , 9	2 46 33.57	9.529	84 25 26.0	0.791*n*	+0.10	− 4.0	19
	17	7 26 37	− 0 50 63	+ 2 35.6	12 , 9	2 49 38.38	9.559	83 18 2.2	0.786*n*	+0.04	− 4.3	20
	23	7 50 6	− 0 10.08	− 0 28.9	12 , 9	2 53 10.39	9.591	82 9 51.6	0.791*n*	−0.01	− 4.6	21
	28	7 40 2	− 3 39.68	− 1 45.7	6 , 8	2 56 25.88	9.596	81 12 49.6	0.790*n*	−0.03	− 5.0	22
	30	7 43 0	− 2 16.69	+ 6 27.7	9 , 6	2 57 49.30	9.601	80 49 49.0	0.792*n*	−0.04	− 5.1	23
	31	7 35 31	− 0 51.73	− 1 46.7	12 , 9	2 58 31.43	9.599	80 38 21.4	0.790*n*	−0.05	− 5.1	24

Dates	T m. Besançon	Δ A.R.	Δ D.P.	Cp.	A.R. app.	log f.p.	D.P. app.	log f.p.	Réd. au j.		*
Comète 1914 *a* (Kritzinger)											
1914	h m s	m s	′ ″		h m s		° ′ ″		s	″	
Mars 31	14 26 40	+ 0 4.97	− 3 49.4	12 , 9	16 17 44.13	9.124*n*	98 28 48.0	0.859*n*	+1.81	+17.0	25
Avr. 1	15 21 1	− 0 34.99	− 6 28.6	10 , 9	16 20 59.81	8.576*n*	97 54 13.6	0.859*n*	+1.82	+17.0	26
1	15 40 7	− 0 32.48	− 6 53.9	9 , 6	16 21 2.32	7.625*n*	97 53 48.3	0.857*n*	+1.82	+17.0	26
15	11 48 4	− 0 46.43	+ 1 40.8	12 , 9	17 9 31.36	9.527*n*	87 59 23.7	0.802*n*	+1.93	+18.4	27
23	12 28 55	+ 1 21.88	+ 2 12.7	12 , 9	17 42 1.71	9.474*n*	80 29 23.9	0.754*n*	+1.96	+18.7	28
23	13 6 0	+ 1 28.21	+ 0 40.2	12 , 9	17 42 8.04	9.397*n*	80 27 51.4	0.747*n*	+1.96	+18.7	28
27	13 14 56	− 2 19.60	− 6 6.7	12 , 16	17 59 30.32	9.385*n*	76 25 39.5	0.711*n*	+1.94	+18.6	29
28	13 4 5	− 0 12.98	+ 1 20.8	12 , 9	18 3 54.74	9.415*n*	75 24 58.1	0.705*n*	+1.94	+18.7	30
Mai 2	12 41 48	− 1 40.70	+ 2 16.6	12 , 9	18 22 0.12	9.477*n*	71 21 19.9	0.678*n*	+1.92	+18.5	31
15	10 21 29	− 0 37.98	− 1 26.0	12 , 9	19 23 8.75	9.664*n*	59 27 6.4	0.714*n*	+1.84	+17.0	32
18	13 16 58	− 0 24.43	− 2 33.0	14 , 9	19 37 59.41	9.481*n*	57 4 53.7	0.462*n*	+1.82	+16.4	33
19	10 56 46	− 0 55.61	− 2 7.5	12 , 9	19 42 15.86	9.667*n*	56 26 13.4	0.654*n*	+1.81	+16.2	34
20	10 46 11	− 0 7.78	− 6 7.5	12 , 8	19 46 55.98	9.675*n*	55 45 48.7	0.665*n*	+1.81	+16.0	35
21	11 7 59	+ 1 40.74	− 1 6.1	9 , 12	19 51 40.33	9.665*n*	55 5 36.3	0.629*n*	+1.81	+15.8	36
22	11 43 9	+ 3 11.38	− 0 1.2	9 , 12	19 56 25.84	9.650*n*	54 26 38.6	0.568*n*	+1.82	+15.6	37
Juin 17	10 41 11	− 1 17.12	+ 6 50.0	12 , 12	21 38 21.61	9.741*n*	45 41 2.8	0.584*n*	+1.89	+ 7.9	38
20	10 29 55	+ 2 40.42	− 0 58.3	9 , 12	21 47 9.39	9.745*n*	45 24 25.2	0.596*n*	+1.97	+ 7.0	39
25	11 39 41	− 0 7.74	+ 2 24.5	12 , 8	22 0 27.89	9.696*n*	45 11 6.8	0.411*n*	+2.05	+ 5.2	40
26	12 24 15	+ 0 11.46	+ 0 9.7	12 , 9	22 2 56.87	9.637*n*	45 10 28.6	0.272*n*	+2.07	+ 4.9	41
27	12 8 40	+ 2 29.54	+ 0 15.3	9 , 12	22 5 14.99	9.658*n*	45 10 33.9	0.317*n*	+2.11	+ 4.6	41
29	11 22 53	− 2 51.82	− 7 50.9	9 , 12	22 9 37.62	9.705*n*	45 12 36.7	0.439*n*	+2.12	+ 3.8	42
30	12 27 52	− 0 39.27	− 5 48.1	12 , 9	22 11 50.21	9.619*n*	45 14 39.2	0.239*n*	+2.16	+ 3.5	42
Juil. 18	10 47 54	− 1 52.19	− 3 27.3	12 , 12	22 37 59.00	9.682*n*	47 26 44.7	0.453*n*	+2.62	− 2.9	43
Comète 1914 *b* (Zlatinsky)											
Mai 19	9 42 30	+ 3 33.33	− 8 1.3	12 , 16	4 25 29.83	9.630	40 49 25.2	0.875*n*	−0.20	−10.1	44
20	9 38 54	− 1 55.90	+ 2 36.7	12 , 16	4 50 3.92	9.664	41 49 40.1	0.856*n*	−0.02	−11.1	45
21	9 32 0	− 2 36.68	− 1 58.7	12 , 16	5 14 20.84	9.692	43 15 11.2	0.834*n*	+0.15	−11.5	46
22	9 21 13	− 0 43.01	− 6 56.9	12 , 12	5 37 42.99	9.709	45 4 46.0	0.806*n*	+0.30	−11.6	47
Juin 1	9 16 52	− 2 58.06	− 4 48.7	6 , 8	8 4 52.99	9.623	71 37 25.7	0.780*n*	+0.95	− 3.8	48
3	9 31 29	+ 2 8.75	− 2 1.5	12 , 16	8 19 15.93	9.614	76 4 1.1	0.794*n*	+0.93	− 2.3	49
(52) *Europa*											
Juin 17	11 41 6	+ 0 57.17	+ 6 11.5	12 , 9	18 8 50.36	8.924*n*	106 42 8.3	0.897*n*	+3.41	+ 8.1	50
(60) *Echo*											
Avr. 28	10 52 33	− 0 32.59	+ 3 25.6	9 , 6	12 54 26.86	8.590	94 30 15 3	0.840*n*	+2.37	+17.0	51
(114) *Kassandra*											
Juin 26	11 9 49	− 1 33.69	+ 8 5.1	9 , 9	16 27 8.12	9.026	104 9 58.8	0.886*n*	+3.26	+13.7	52
27	10 37 12	− 2 10.59	+ 8 22.7	9 , 9	16 26 31.22	8.751	104 10 16.4	0.888*n*	+3.26	+13.7	52
(145) *Adeona*											
Avr. 27	12 36 41	− 3 5.63	+ 2 18.9	9 , 12	15 36 2.30	8.835*n*	99 5 10.9	0.864*n*	+2.51	+17.5	53
28	12 25 42	− 3 58.02	+ 1 47.3	9 , 11	15 35 9.93	8.899*n*	99 4 39.3	0.864*n*	+2.53	+17.5	53

Date	T. m. Besançon	Δ A.R.	Δ D.P.	Cp.	A.R. app.	log f.p.	D.P. app.	log f.p.	Réd. au j.		*
					(187) *Lamberta*						
1914	h m s	m s	′ ″		h m s		° ′ ″		s	″	
Mars 31	11 49 27	+ 1 52.66	+ 6 58.9	12 , 11	11 37 4.57	8.913	79 18 54.9	0.720*n*	+2.37	+12.5	54
					(221) *Eos*						
Avr. 27	9 59 23	− 0 19.72	+ 2 34.8	12 , 9	12 28 7.39	8.185*n*	80 28 44.9	0.729*n*	+2.43	+13.8	55
28	10 6 4	− 0 49.91	+ 0 1.9	12 , 9	12 27 37.20	7.789	80 26 11.9	0.728*n*	+2.43	+13.7	55
					(225) *Henrietta*						
Juin 26	11 55 36	+ 1 37.63	− 5 22.9	12 , 12	17 17 17.94	8.985	83 16 27.6	0.758*n*	+3.11	+ 9.0	56
27	11 31 56	+ 0 59.02	− 6 49.1	12 , 9	17 16 39.34	8.801	83 15 1.2	0.757*n*	+3.12	+ 8.8	56
					(268) *Adorea*						
Mai 15	11 29 38	+ 0 32.43	− 0 54.0	12 , 9	15 53 39.19	8.975*n*	106 49 44.9	0.897*n*	+2.85	+16.4	57
Juin 25	10 48 25	− 1 1.24	− 5 59.5	12 , 9	15 26 38.70	9.223	105 52 9.7	0.889*n*	+3.01	+17.0	58
26	10 26 9	− 3 8.99	− 3 42.6	12 , 9	15 26 20.85	9.136	105 52 12.8	0.891*n*	+3.02	+16.9	59
					(308) *Polyxo*						
Avr. 15	12 13 1	− 0 58.06	+ 2 4.9	9 , 9	13 48 27.04	7.607*n*	98 5 56.0	0.858*n*	+2.38	+18.0	60
					(349) *Dembowska*						
Mars 31	11 2 16	− 1 49.69	− 0 49.6	12 , 9	10 46 20.02	8.957	73 12 55.3	0.652*n*	+2.39	+ 8.5	61
					(444) *Gyptis*						
Juin 29	12 10 49	− 1 54.28	−12 40.6	9 , 9	21 1 4.92	9.366	90 54 0.0	0.816*n*	+2.98	− 4.6	62
30	11 53 30	− 2 9.92	−15 7.0	9 , 9	21 0 49.31	9.399*n*	90 51 33.4	0.815*n*	+3.01	− 4.8	62
					(747) 1913 *QZ*						
Avr. 27	11 59 51	+ 2 36.07	+ 7 36.8	9 , 12	14 43 4.65	8.604*n*	80 41 44.4	0.733*n*	+2.56	+18.3	63
28	11 58 4	+ 1 52.72	+ 3 51.2	12 , 9	14 42 21.31	8.548*n*	80 37 58.7	0.732*n*	+2.57	+18.2	63

Positions moyennes des étoiles de Comparaison.

*	A.R. 1913-14.0	D.P. 1913-14.0	Autorités	*	A.R. 1914.0	D.P. 1914.0	Autorités
	h m s	° ′ ″			h m s	° ′ ″	
1	3 0 5.94	97 12 2.3	*A.G. Wien-Ottak.* 696	33	19 38 22.02	57 7 10.3	*A.G. Leiden* 7578
2	2 57 50.86	96 49 59.5	*A.G. Wien-Ottak.* 685	34	19 43 9.66	56 28 4.7	*A.G. Leiden* 7636
3	2 43 53.76	93 58 37.4	*A.G. Strasbourg* 672	35	19 47 1.95	55 51 40.2	*A.G. Leiden* 7700
4	2 45 23.28	93 54 15.4	*A.G. Strasbourg* 680	36	19 49 57.78	55 6 26.6	*A.G. Leiden* 7740
5	2 47 2.37	93 21 5.1	*A.G. Strasbourg* 684	37	19 53 12.64	54 26 24.2	*A.G. Lund* 8855
6	2 43 14.29	92 56 31.6	*A.G. Strasbourg* 671	38	21 39 36.84	45 34 4.9	*A.G. Bonn* 15890
7	2 39 7.93	92 53 48.6	*A.G. Strasbourg* 661	39	21 44 27.00	45 25 16.5	*A.G. Bonn* 15982
8	2 37 56.62	92 43 9.9	*A.G. Strasbourg* 656	40	22 0 33.58	45 8 37.1	*A.G. Bonn* 16311
9	2 40 18.47	92 19 30.7	*A.G. Strasbourg* 664	41	22 2 43.34	45 10 14.0	*A.G. Bonn* 16350
10	2 38 54.79	91 30 1.7	*A.G. Nicolajew* 559	42	22 12 27.32	45 20 23.8	*A.G. Bonn* 16527
11	2 40 9.32	91 24 47.4	*A.G. Nicolajew* 566	43	22 39 48.57	47 30 14.9	*A.G. Bonn* 17045

Positions moyennes des étoiles de Comparaison (Continued).

*	A.R. 1913-14.0	D.P. 1913-14.0	Autorités	*	A.R. 1914.0	D.P. 1914.0	Autorités
	h m s	° ′ ″			h m s	° ′ ″	
12	2 37 42.30	90 58 26.4	*A.G. Nicolajew* 555	44	4 21 56.70	40 57 36.6	*A.G. Bonn* 3627
13	2 36 57.21	90 27 40.3	*A.G. Nicolajew* 551	45	4 51 59.84	41 47 14.5	*A.G. Bonn* 3986
14	2 40 32.37	90 21 58.3	*A.G. Nicolajew* 568	46	5 16 57.37	43 17 21.4	*A.G. Bonn* 4397
15	2 40 6.77	89 59 20.7	*A.G. Nicolajew* 565	47	5 38 25.70	45 11 54.5	*A.G. Bonn* 4689
16	2 36 33.07	89 26 15.2	*A.G. Nicolajew* 548	48	8 7 50.10	71 42 18.2	*A.G. Berlin A* 3236
17	2 36 15.13	89 10 40.6	*A.G. Nicolajew* 547	49	8 17 6.25	76 6 4.9	*A.G. Leipzig I* 3375
18	2 37 51.83	87 51 35.6	*A.G. Albany* 752	50	18 7 49.70	106 35 48.7	*A.G. Washington* 6597
19	2 46 57.42	84 30 40.4	*A.G. Leipzig II* 1053	51	12 54 57.08	94 26 32.7	*A.G. Strasbourg* 4728
20	2 50 28.97	83 15 30.9	*A.G. Leipzig II* 1077	52	16 28 38.55	104 1 40.0	*A.G. Washington* 5964
21	2 53 20.48	82 10 25.1	*A.G. Leipzig II* 1107	53	15 39 5.42	99 2 34.5	*A.G. Wien-Ottak.* 5488
22	3 0 5.59	81 14 40.3	*A.G. Leipzig II* 1148	54	11 35 9.54	79 11 43.5	*A.G. Leipzig I* 4355
23	3 0 6.03	80 43 26.4	*A.G. Leipzig II* 1147	55	12 28 24.68	80 25 56.3	*A.G. Leipzig II* 6159
24	2 59 23.21	80 40 13.2	*A.G. Leipzig II* 1143	56	17 15 37.20	83 21 41.5	*A.G. Leipzig II* 7748
25	16 17 37.35	98 32 20.4	*A.G. Wien-Ottak.* 5677	57	15 53 3.91	106 50 22.5	*A.G. Washington* 5824
26	16 21 32.98	98 0 25.2	*A.G. Wien-Ottak.* 5699	58	15 27 36.93	105 57 52.2	rapp. à star 59
27	17 10 15.86	87 57 24.5	½ (*A.G. Alb.* 5700 + Mu_1 13701)	59	15 29 26.82	105 55 38.5	*A.G. Washington* 5706
28	17 40 37.87	80 26 52.5	*A.G. Leipzig II* 8022	60	13 49 22.72	98 3 33.1	*A.G. Wien-Ottak.* 4943
29	18 1 47.98	76 31 27.6	*A.G. Leipzig II* 6416	61	10 48 7.32	73 13 36.4	*A.G. Berlin A* 4285
30	18 4 5.78	75 23 18.6	*A.G. Leipzig I* 6437	62	21 2 56.22	91 6 45.2	*A.G. Nicolajew* 5367
31	18 23 38.90	71 18 44.8	*A.G. Berlin A* 6807	63	14 40 26.02	80 33 49.3	*A.G. Leipzig II* 6790
32	19 23 44.89	59 28 15.4	*A.G. Leiden* 7357				

REMARQUES

Comète 1913 *f*

Déc. 19. Pendant la première série la lunette est secouée par le vent qui souffle du *NE*. La deuxième série est meilleure, la lunette étant mieux abritée les images sont plus calmes. La Comète se présente comme une petite nébulosité ayant au maximum 25″ de diamètre et d'un éclat de 11^e à 11^e.5 grandeur. Une condensation, à luminosité variable, avoisine le centre. Absence de queue.

Janv. 22. La Comète, estimée de grandeur 10.5 est ronde et a un noyau bien défini.

24. Une vague queue se dessine vers *ENE*.

31. Malgré la présence de la *Lune* la Comète est facile à mesurer.

Févr. 5. La Comète, de grandeur 9.5, est bien observable malgré la *Lune* presque pleine; le noyau de la Comète est flou mais bien apparent.

20. La Comète est de 9^e grandeur; la tête ronde a 1′ de diamètre. La condensation est bien définie. Pas de queue.

Mars 11. Par la présence de la pleine *Lune*, le noyau de la Comète est seul visible.

23. La Comète est voisine de l'horizon. Le noyau apparaît assez brillant et allongé. La chevelure est peu visible.

31. La Comète, de 9^e grandeur, a un noyau bien défini, mais flou et large de 5″ à 6″; la chevelure est invisible dans le crépuscule et le voisinage de la *Lune*.

Comète 1914 *a*

Mars 31. La Comète a l'aspect d'une pâle nébulosité de 12^e grandeur, allongée vers *WSW*, large de 45″ et pourvue d'une faible condensation.

Avr. 1. Le ciel étant nébuleux, la Comète est à peine visible.

15. La Comète, de grandeur 10.5, est étalée sur 2′ à 3′; la condensation est mal définie.

27. La Comète est de 10^e grandeur, peu brillante; le noyau est flou, la chevelure s'allonge vers le *SW*.

Comète 1914 *a* (*Continued*).

Mai 15. La Comète est de 9.5 grandeur; la tête, ronde, est large de $1'.5$.

22. L'éclat de la Comète apparaît plus faible: de 10^e à 11^e grandeur.

Juin 17. La Comète a augmenté d'éclat, elle est de 9^e à $9^e.5$ grandeur. La tête, ronde, mesure $2'$ de diamètre, la condensation est centrale et mal définie.

26. La Comète est de grandeur 9.5; la tête est ronde et large de $1'$; la condensation est centrale, bien prononcée, mais peu brillante.

29. L'éclat de la Comète est changeant et voisin de la 10^e grandeur.

Juil. 18. La Comète, de grandeur 11.5, a une tête ronde de $1'$ de diamètre; le noyau est diffus et étalé.

Comète 1914 *b*

Mai 19. La Comète a une tête brillante, ronde, de $4'$ de diamètre, avec forte condensation centrale et un noyau bien défini et $4''$ à $5''$ d'épaisseur, mais d'un éclat variable et voilé. Une queue principale, peu lumineuse, mince et rectiligne disparaît à 1° de la tête par un angle au pôle de 17°. La Comète est estimée de 5^e grandeur.

20. Le noyau stellaire est toujours très net; la queue est moins visible que la veille.

21. La Comète a peu changé d'éclat. La queue s'écarte en éventail par $p = 36°$.

Juin 1. La Comète est de 7^e grandeur. La condensation seule est visible: l'astre se trouvant dans le crépuscule, près de l'horizon et à proximité de la *Lune*.

3. Pour les mêmes causes que le 1^{er} Juin, la Comète est peu visible.

Observatoire de Besançon, 1918, Janvier 30.

GROUPS OF ASTEROIDS PROBABLY OF COMMON ORIGIN,

BY KIYOTSUGU HIRAYAMA.

On examining the distributions of the asteroids with respect to their orbital elements, particularly to the mean motion (n), the inclination (i) and the eccentricity (e), we notice condensations here and there. In general, they seem to be due to chance. But there are some which are too conspicuous to be accounted for by the laws of probability alone.

As an example of such peculiar groups, I shall take the condensation near $n = 730''$. Out of 790 orbits given in the *Berliner Jahrbuch* for 1917, taking 37 between $720''$ and $740''$ of the mean motion, and classifying them according to the inclination, we count as follows:—

i	Actual No.	Total	Prop. No.	Diff.	Corr. Prop. No.	Diff.
0°— 4°	16	149	7	+9	5	+11
4 — 8	6	213	10	−4	7	− 1
8 — 12	6	194	9	−3	6	0
12 — 16	6	131	6	0	4	+ 2
16 — 20	3	55	3	0	2	+ 1
20 —	0	48	2	−2	2	− 2
Sum	37	790	37	0	26	+11

Sixteen orbits between 0° and 4° of i are surely out of proportion. Assuming the existence of a group physically connected and computing the proportional number according to the remaining $37-16=21$, we see that the probable number of the asteroids belonging to the group is eleven.

Classifying then the sixteen asteroids by the angle of eccentricity (φ), we get

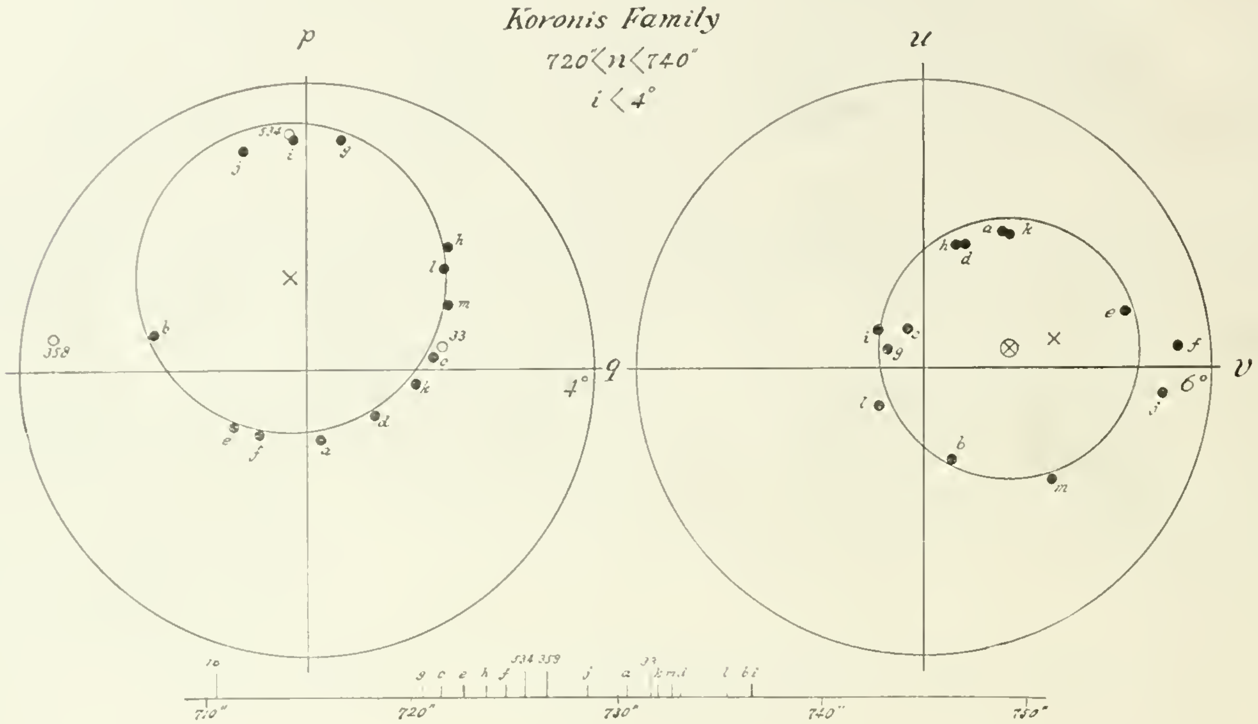
φ	Actual No.	Total	Prop. No.	Diff.
0°— 4°	10	123	2	+8
4 — 8	4	263	5	−1
8 — 12	1	235	5	−4
12 — 16	0	133	3	−3
16 — 20	1	28	1	0
20 —	0	8	0	0
Sum	16	790	16	0

Ten orbits between 0° and 4° of φ are again out of proportion.

This is not all. Taking the sixteen asteroids, if we plot the poles of the orbital planes on a diagram,

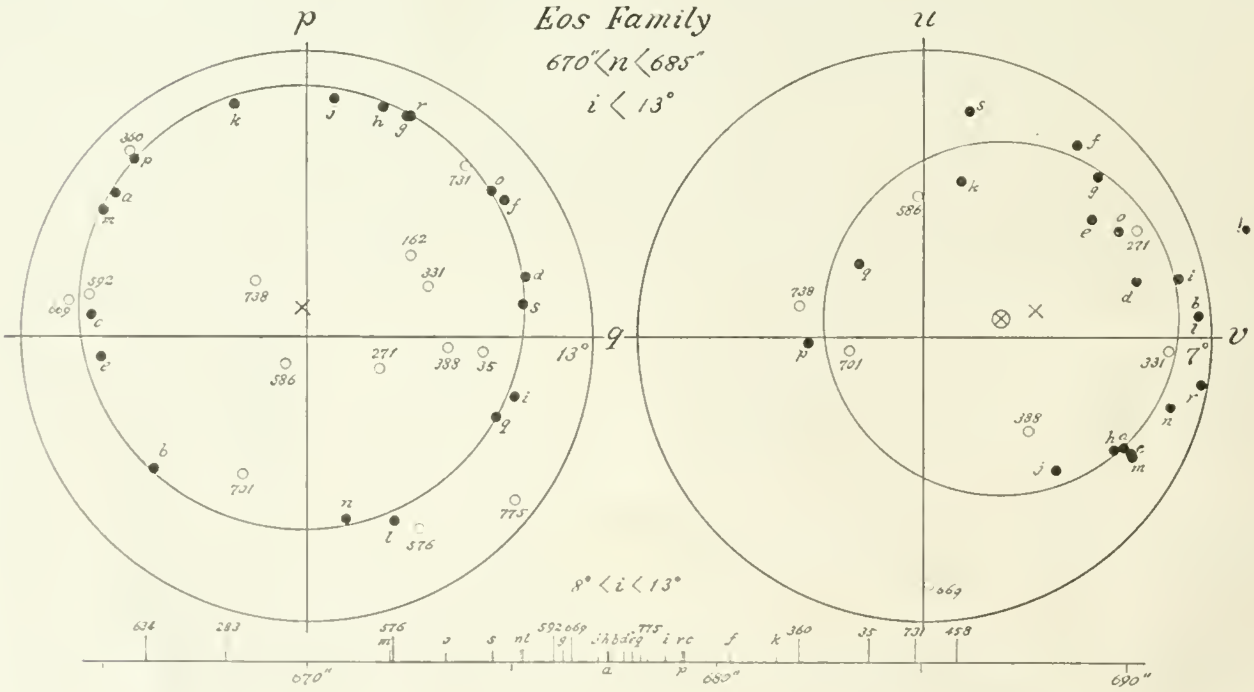
fifteen points, most curiously, are disposed on a circumference. The center very nearly coincides with the pole of *Jupiter's* orbit. This is certainly a remarkable coincidence.

Still curiously, if we draw similar diagram taking the eccentricity and the longitude of perihelion (ϖ) instead of the inclination and the longitude of the node (☊), thirteen points again are distributed on a circumference,


Koronis Family

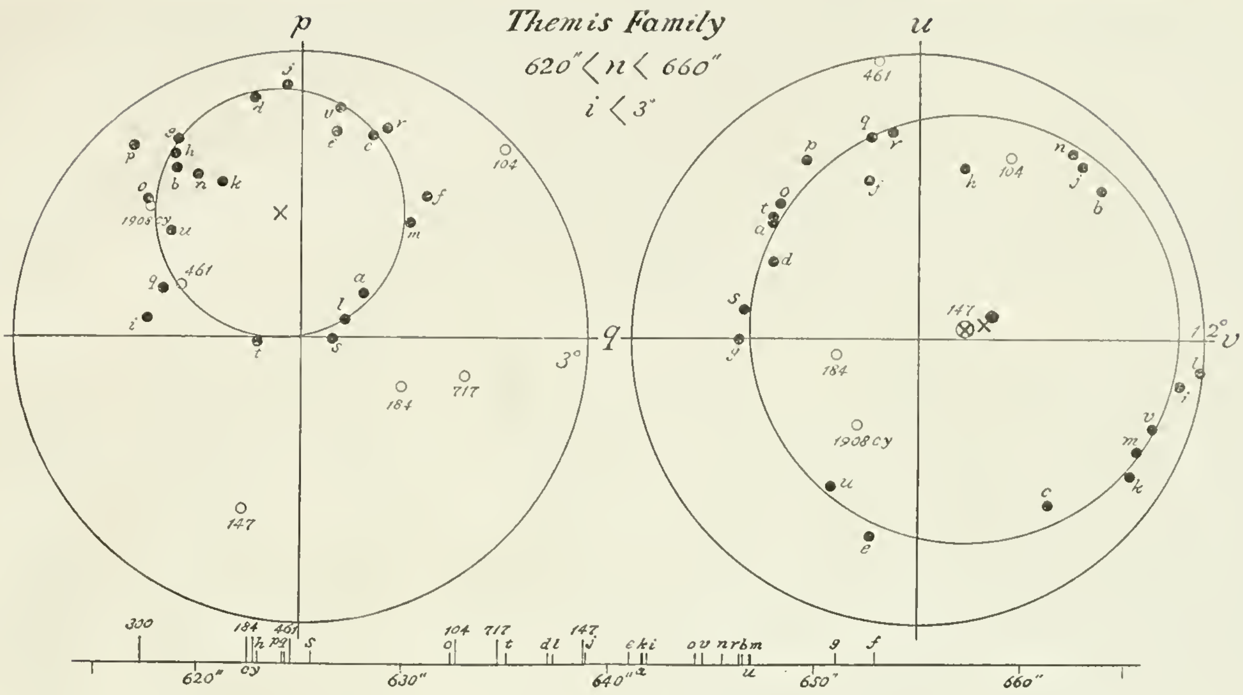
$720'' < n < 740''$

$i < 4°$


Eos Family

$670'' < n < 685''$

$i < 13°$



although not quite so marked as in the case of the inclination. The center in this case does not coincide with the corresponding point for *Jupiter* save the direction from the origin. A group of thirteen asteroids — two more than expected — is found in this manner.

Referring to the theory which will be mentioned below, there can be little doubt about the physical relation connecting these asteroids. So I venture to name the group the *Koronis Family*, associating the name of the asteroid (158) which was discovered first.

I find two more families which will be named the *Eos* (221) *Family* and the *Themis* (24) *Family*. The first contains 19 asteroids within the limits

$$671'' < n < 682'', \quad 8^\circ.6 < i < 11.3, \quad 2^\circ.3 < \varphi < 6^\circ.9.$$

The second contains 22 within the limits

$$622'' < n < 653'', \quad 0^\circ.3 < i < 2^\circ.7, \quad 6^\circ.8 < \varphi < 11^\circ.8.$$

The explanation of the *asteroid families* seems not very hard. Considering the perturbations of *Jupiter*, the equations giving the secular variations of the orbital plane of the asteroid are:—

$$\begin{aligned} p &= \tan i \sin \Omega = p' + N \sin (ht + \beta), \\ q &= \tan i \cos \Omega = q' + N \cos (ht + \beta), \end{aligned}$$

where p' and q' are the corresponding quantities for *Jupiter*, and, N and β are arbitrary constants depending on the initial values of p and q. The quantity h is a function of the semi-major axis (a) and is determined by the equations

$$\frac{h}{n'} = -\frac{3m'}{4\mu}\frac{n'}{n} S_1$$

$$S_1 = 1 + \frac{3}{2}\frac{5}{4}\left(\frac{a}{a'}\right)^2 + \frac{3\cdot5}{2\cdot4}\frac{5\cdot7}{4\cdot6}\left(\frac{a}{a'}\right)^4 + \cdots\cdots.$$

denoting by n' and a' the mean motion and the semi-major axis of *Jupiter* and by $\frac{m'}{\mu}$ the ratio of the masses of *Jupiter* and the *Sun*. Accordingly, if we regard p and q as rectangular coördinates, the point (p, q) describes a circle about the center (p', q') with the radius N and the angular velocity h. The motion is retrograde since h is negative.

Now suppose that an asteroid was broken into a number of fragments at a certain epoch. Suppose also that the additional velocities of the fragments are small compared with the original velocity. Then if we denote the elements of the original asteroid by a, e etc., those of the fragments will be denoted by

$$a + \delta a, \qquad e + \delta e, \quad \text{etc.}$$

The corresponding values of N, β and h become $N + \delta N$, $\beta + \delta\beta$ and $h + \delta h$. The effect of δN and $\delta\beta$ is always small; but that of δh becomes larger and larger as the time increases. The result after a very long duration will be that the points (p, q) of the fragments are distributed irregularly on the whole circumference of a circle whose radius is approximately equal to N and whose center occupies the point (p', q').

As for the eccentricity we have the equations

$$u = e \sin \varpi = ku' + M \sin (gt + \alpha),$$
$$v = e \cos \varpi = kv' + M \cos (gt + \alpha),$$

where u' and v' are the corresponding values for *Jupiter*. The only difference compared with the case of the inclination is that the quantities u' and v' are multiplied by a constant k which depends on a or e. The expression of k is

$$k = \frac{5}{4}\frac{a}{a'}\frac{S_2}{S_1}$$

where

$$S_2 = 1 + \frac{3}{2}\frac{7}{6}\left(\frac{a}{a'}\right)^2 + \frac{3\cdot5}{2\cdot4}\frac{7\cdot9}{6\cdot8}\left(\frac{a}{a'}\right)^4 + \cdots .$$

We have also $g = -h$ and therefore the motion is direct.

The approximate mean values of h, k, etc., are computed as follows:

Family	*Koronis*	*Eos*	*Themis*
n	725″	675″	638″
$-n'\ h$	1710	1440	1260
k	0.660	0.692	0.716
Period in years	20300	17100	15000

The centers of the motion determined by these values of k are marked on the diagrams with ⊗. It may be seen that these points represent the centers of the circular distributions pretty closely. Our theory is thus verified.

The numbers of the asteroids belonging to each family are as follows:—

Family	*Koronis*	*Eos*	*Themis*
a	158	221	24
b	167	320	62
c	208	339	90
d	243	450	171
e	263	513	222
f	277	520	223
g	311	529	268
h	321	562	316
i	452	573	379
j	462	579	383
k	658	590	431
l	720	608	468
m	761	633	492
n	. . .	639	515
o	. . .	651	526
p	. . .	653	555
q	. . .	661	561
r	. . .	742	621
s	. . .	766	637
t	. . .	. . .	656
u	. . .	. . .	710
v	. . .	. . .	767

Astronomical Observatory, Tokyo, May 16, 1918.

NEW ASTRONOMICAL WORK.

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DEFINITIVE ORBIT OF COMET 1786 II,

By Margaretta Palmer.

In its physical aspect and the form of its orbit, the comet 1786 II presents no striking features. Several facts, however, commend it to our notice. Although at the time of its discovery, about a month after perihelion and when receding from the earth, this comet was just at the limit of visibility to the naked eye and grew fainter after two weeks of observation, it was, nevertheless, observed for a period of eighty-two days. The longest two series of observations were made by two of the best observers of the period with excellent instrumental facilities for that age.

Comet 1786 II was discovered about ten o'clock in the evening of August 1, 1786, by Caroline Herschel, at her brother's observatory at Slough, near Windsor, England (*Phil. Trans.* 77, p. 2 *et al.*). This was the first discovery of the kind made by Miss Herschel, who afterwards independently discovered seven other comets. She describes it as appearing "like a very bright, but round, small nebula." (*Memoir and Correspondence of Caroline Herschel*, p. 71).

As seen by the best observers under favorable conditions, with the best telescopes of the day, it had a somewhat distinct nucleus, surrounded by a badly defined nebulosity, and, during a short portion of its visibility, a tail. For about two weeks after discovery this comet was just at the limit of visibility to the naked eye. Full details of its physical appearance and theoretical brilliancy are given by Holetschek (*Grösse und Helligkeit der Kometen* 2, 1905, p. 15).

Neglecting Miss Herschel's observations, by diagram only, this comet was observed at six observatories, by six observers, on sixty-one nights. The comet passed its perihelion July 8, and was nearest the earth July 24, when it was about one hundred and six millions of miles from our planet. During the period of visibility it traversed 71° in right ascension, 10° in declination, and 40° 30′ of heliocentric arc.

The coördinates of the *Sun*, given below, were computed from Newcomb's *Tables of the Sun* for Berlin mean noon of every second day. As this table was completed in advance of the planning of the entire investigation, it was less laborious to make use of it than to repeat the computation for Greenwich mean noon, which should have been chosen. The values of the longitude, latitude, log. R, sidereal time of mean noon, and equation of time were checked by computing for eight-day intervals from Hansen's *Tables*.

Sun Places for Berlin Mean Noon, Equator and Mean Equinox 1786.0.

Date	Longitude	Latitude	log R	X	Y	Z	Siderial Time of Mean Noon	Equation of Time
1786	° ′ ″	″					h m s	
Aug. 1	129 13 30.74	−0.96	0.0062446	−0.6415286	+0.7208859	+0.3129532	8 40 48.92	
3	131 8 26.82	.86	0.0061124	0.6672365	0.7005992	0.3041466	48 42.03	
5	133 3 26.11	.69	0.0059735	0.6921843	0.6795209	0.2949969	56 35.15	
7	134 58 28.85	.43	0.0058290	0.7163446	0.6576769	0.2855151	9 4 28.27	
9	136 53 35.66	−0.17	0.0056797	0.7396923	0.6350903	0.2757110	12 21.39	m s
11	138 48 47.13	+0.07	0.0055261	0.7622027	0.6117859	0.2655950	20 14.50	+1 46.74
13	140 44 4.08	.21	0.0053685	0.7838501	0.5877869	0.2551771	28 7.59	26.58
15	142 39 27.14	.22	0.0052063	0.8046122	0.5631169	0.2444672	36 0.69	4.31
17	144 34 56.81	+0.11	0.0050387	0.8244604	0.5378004	0.2334760	43 53.81	3 40.02
19	146 30 33.35	−0.10	0.0048649	0.8433698	0.5118639	0.2222151	51 46.93	13.78
21	148 26 16.67	.35	0.0046838	0.8613130	0.4853355	0.2106969	59 40.06	2 45.68

Date	Longitude	Latitude	log R	X	Y	Z	Siderial Time of Mean Noon	Equation of Time
1786	°	″					h m s	m s
Aug. 23	150 22 6.61	.60	0.0044950	0.8782666	0.4582454	0.1989349	10 7 33.16	15.83
25	152 18 2.80	.79	0.0042985	0.8942068	0.4306261	0.1869435	15 26.26	1 44.21
27	154 14 5.02	.87	0.0040949	0.9091142	0.4025112	0.1747376	23 19.36	11.01
29	156 10 13.06	.84	0.0038846	0.9229690	0.3739339	0.1623315	31 12.46	0 36.26
31	158 6 26.86	.71	0.0036687	0.9357562	0.3449296	0.1497406	39 5.57	+ 0.10
Sept. 2	160 2 46.48	.51	0.0034482	0.9474612	0.3155311	0.1369791	46 58.69	− 37.38
4	161 59 12.08	−0.25	0.0032242	0.9580710	0.2857748	0.1240621	54 51.80	1 15.99
6	163 55 43.93	+0.01	0.0029976	0.9675740	0.2556924	0.1110038	11 2 44.91	55.61
8	165 52 22.52	.21	0.0027696	0.9759607	0.2253176	0.0978183	10 38.01	2 36.07
10	167 49 8.57	.30	0.0025407	0.9832214	0.1946828	0.0845192	18 31.11	3 17.18
12	169 46 2.73	.28	0.0023109	0.9893450	0.1638199	0.0711207	26 24.21	58.75
14	171 43 5.58	+0.12	0.0020795	0.9943212	0.1327617	0.0576361	34 17.32	4 40.59
16	173 40 17.35	−0.11	0.0018458	0.9981394	0.1015425	0.0440821	42 10.44	5 22.53
18	175 37 38.04	.35	0.0016089	1.000790	0.0701991	0.0304736	50 3.56	6 4.47
20	177 35 7.51	.57	0.0013682	1.002265	0.0387683	0.0168274	57 56.66	46.20
22	179 32 45.32	.71	9.0011235	1.002559	+0.9072898	+0.0031609	12 5 49.75	7 27.63
24	181 30 31.15	.73	9.0008750	1.001670	−0.0241976	−0.0105088	13 42.85	8 8.61
26	183 28 21.67	.66	0.0006232	0.9995962	0.0556545	0.0241649	21 35.95	49.00
28	185 26 25.58	.50	0.0003690	0.9963415	0.0870419	0.0377902	29 29.06	9 28.66
30	187 24 33.71	−0.24	0.0001132	0.9919087	0.1183217	0.0513683	37 22.18	10 7.44
Oct. 2	189 22 48.99	+0.03	9.9998568	0.9863034	0.1494563	0.0648833	45 15.29	45.15
4	191 21 11.35	.26	9.9996012	0.9795327	0.1804082	0.0783193	53 8.40	11 21.70
6	193 19 41.12	.43	9.9993476	0.9716052	0.2111430	0.0916613	13 1 1.49	56.82
8	195 18 18.72	.18	9.9990970	0.9625300	0.2416261	0.1048946	8 54.59	12 30.38
10	197 17 1.75	.39	9.9988499	0.9523152	0.2718240	0.1180049	16 47.70	13 2.20
12	199 15 59.77	+0.19	9.9986060	0.9409682	0.3017029	0.1309774	24 40.82	32.03
14	201 15 4.10	−0.05	9.9983645	0.9284976	0.3312275	0.1437962	32 33.94	59.75
16	203 14 17.74	.29	9.9981247	0.9149129	0.3603614	0.1564453	40 27.05	14 25.21
18	205 13 40.52	.46	9.9978859	0.9002264	0.3890675	0.1689083	48 20.15	48.23
20	207 13 11.96	.55	9.9976476	0.8844532	0.4173078	0.1811688	56 13.25	15 8.77
22	209 12 51.69	.52	9.9974098	0.8676098	0.4450456	0.1932105	14 4 6.35	26.67
24	211 12 39.16	.39	9.9971728	0.8497162	0.4722443	0.2050175	11 59.45	41.84
26	213 12 33.93	−0.18	9.9969370	0.8307910	0.4988688	0.2165749	19 52.57	54.20
28	215 12 35.58	+0.08	9.9967033	0.8108668	0.5248849	0.2278679	27 45.69	16 3.66
30	217 12 43.81	+0.35	9.9964725	−0.7899590	−0.5502603	−0.2388828	35 38.80	

1786.0 $\epsilon = 23° 28' 1''.66$

Elements were computed for the comet 1786 II by MÉCHAIN and by REGGIO (CARL'S *Repertorium der Cometen-Astronomie*, p. 132). Of these, MÉCHAIN'S, which more nearly represent the observations, were taken as the point of departure for this investigation.

I first corrected those elements by the method of variation of the geocentric distances (BAUSCHINGER'S *Bahnbestimmung der Himmelskörper*, pp. 316 foll.). In this preliminary work the observations made during the latter part of October, when the comet was seen with difficulty, were omitted. By using the observations of MASKELYNE and WOLLASTON August 5 and August 6, the observations of MASKELYNE and MESSIER September 11, 14, 15, 16, and 17, and the observations of MASKELYNE and MESSIER October 14, 16, and 17, normal places were formed for August 6.0, September 14.5, and October 15.5. The provisional elements thus obtained, together with MÉCHAIN'S elements, the latter with the value of T converted into Berlin mean time and ω substituted for π, are given below:—

MÉCHAIN'S ELEMENTS.

$$
\begin{aligned}
T &= 1786,\ \text{July } 7.94764 \text{ B.M.T.} \\
\omega &= -34°\ 57'\ 4'' \\
\Omega &= 194\ \ 22\ \ 49 \quad \Big\}\ 1786.0 \\
i &= 50\ \ 51\ \ 28 \\
\log.\ q &= 9.612889
\end{aligned}
$$

Provisional Elements.

$$\begin{array}{rcll} T & = & 1786,\ \text{July } 7.93182 \text{ B.M.T.} & \\ \omega & = & -34\ \ 59'58''.5 & \\ \Omega & = & 194\ \ 22\ 15\ .5 & \Big\} 1786.0 \\ i & = & 50\ \ 55\ 11\ .7 & \\ \log.\, q & = & 9.612943 & \end{array}$$

Rectangular heliocentric equatorial coördinates (provisional elements): —

$$\begin{array}{l} x = [9.6046527] \sin(244^\circ\ 13'\ \ 9''.35 + v) \sec^2\tfrac{1}{2}v \\ y = [9.5665657] \sin(159\ \ 44\ \ 35\ \ .18 + v) \sec^2\tfrac{1}{2}v \\ z = [9.2935876] \sin(313\ \ \ 2\ \ 45\ \ .69 + v) \sec^2\tfrac{1}{2}v \end{array} \Bigg\} 1786.0$$

The comet 1786, II, was observed at Chislehurst by Wollaston (*Phil. Trans.* 77, p. 57), at Greenwich by Maskelyne (*Astr. Obs. Greenwich*, II, *Zenith Sector*, p. 29), at Milan by Reggio and Cesaris (*Ephem. Mil.* 1789. App. pp. 145, 212), at Paris, Observatoire Royale, by Méchain (*B. J.* 1790, p. 181), and by Messier both at Paris, Observatoire de la Marine, Hôtel de Clugny, and at Château de Saron (*Mémoire de Paris*, 1786, p. 99). The number of observations discussed is 144 in right ascension and 143 in declination. The observations of Cesaris seem to have escaped the notice of both Holetschek and Galle (*Verzeichniss der Elemente der bisher berechneten Cometenbahnen*). Holetschek refers to the observations of Reggio, whereas in Carl's *Repertorium* there is an imperfect reference to the observations of Cesaris.

In so far as possible, the observations were re-reduced. The times were corrected for aberration (distance unity 498″.5). The parallax factors were computed by means of Bauschinger's Tafeln (solar parallax 8″.80). Refractions were computed for all the observations except Méchain's.

The places of the comparison stars for 1786.0 were formed by a careful comparison of the catalogue places. The system adopted is that of the *Neue Fundamental Katalog*. For stars not found in the *N. F. K.*, in *Bradley-Auwers'*, or in Boss' *Catalogue of 6188 Standard Stars* practically all catalogue positions were considered and positions deduced, after assigning weights in accordance with those given by recognized authorities in regard to star catalogues. Whenever proper motions had been well determined they have been used in the reductions. In other cases I have deduced them.

I am indebted to the *Astronomer Royal* for examining Wollaston's manuscripts in the posession of the Royal Society, but for this comet no data in addition to the published observations could be found. These observations, therefore, though very unsatisfactory, were used by applying the given differences, comet-star, to the apparent positions of the stars as newly deduced, giving the weight zero in the final solution to observations which showed great divergence from the other positions.

For Maskelyne's observations, the given means of differences, comet-star, were first checked and then applied to the newly deduced star positions.

For the observations of Reggio, likewise, the given differences, comet-star, were added to newly deduced positions of the stars.

In Cesaris' observations, the values of the apparent right ascensions and declinations of the comet only are given. The assumption was made that, on evenings when both Cesaris and Reggio observed, the same comparison stars were used and the same star positions employed in reducing the observations. For those dates the positions of the comet given by Cesaris were corrected by the difference between the star positions given by Reggio and the newly deduced positions. As the results thus obtained accorded better with the other observations, the places thus corrected were employed.

Inasmuch as Messier seems to have made no attempt to test the perpendicularity of the wires of his micrometer or to determine any other instrumental errors (Burckhardt, *Mém. de l'Institut*, 1801, p. 327), and Krueger (*Acta Societatis Scientarum Fennicæ*, IX, p. 38), found in regard to the same instrument in 1785 that the relative position of the wires varied 33′ from being at right angles, I applied various tests to Messier's Paris observations. By Krueger's method, the resulting value for $\Delta\alpha$, $-0''.3892 \pm 0''.1623$ multiplied by the difference in declination of the comet and star, is considerably smaller than Krueger's. The result $-0''.2448 \pm 0''.2461$ multiplied by the difference in declination, confirmed his statement that no correction in declination dependent on the difference in declination could be determined. Comparison with Maskelyne's observations showed no systematic difference between the two series. As the latter gave good attention to the adjustment of his instrument, determined the clock corrections accurately (for that period), and made careful measurements, his observations show good agreement among themselves. Messier's observations were, therefore, used as determined by applying the difference, comet-star, to the newly deduced star positions.

Through the courtesy of the Paris Observatory I was informed that the originals of the 32 observations mentioned by Méchain (*B. J.* 1790, p. 181), cannot be found. The eight longitudes and latitudes there given were converted into right ascensions and declinations and compared with the computed values, but were, finally, given weight zero.

Although for observations of no greater accuracy than those under discussion any determination of the weights for the various observers must be open to criticism, such a determination was made by plotting a curve from the differences O − C. Weights were then assigned in accordance with the results thus obtained and proportional to the number of observations combined to form the daily mean, some changes being made in the cases of observations made under unfavorable conditions. The values of E for the different observers are as follows: —

	RIGHT ASCENSION.	DECLINATION.
WOLLASTON	±19″.2	±29″.0
MASKELYNE	± 9 .0	± 8 .6
REGGIO	±20 .2	±28 .4
CESARIS	±18 .0	±13 .0
MESSIER	±13 .2	± 9 .6

The observations were then grouped into seven Normal Places as indicated by the division lines in the following table: —

No.	Berlin Mean Time	Place	$\Delta\alpha\cos\delta$ (O − C)	$p\alpha$	$\Delta\delta$ (O − C)	$p\delta$
			s			
1	Aug. 5.45204	Greenwich	+0.21	4	+ 3.0	3
2	5.46630	Chislehurst	+0.24	1	+ 6.8	0.2
3	5.48390	Chislehurst	−4.95	0	− 0.4	0
4	6.44546	Chislehurst	+0.75	1	+ 7.3	0.5
5	6.46747	Greenwich	−0.40	3	− 2.7	2
6	7.44595	Chislehurst	−4.45	0.5	+39.8	0
7	8.42314	Chislehurst	−4.35	0.5	+55.4	0
8	11.42579	Chislehurst	−0.05	1	+34.3	0
9	11.43438	Greenwich	−0.54	3	− 9.3	2
10	11.43474	Paris	−0.07	2	+ 2.3	3
11	12.45314	Greenwich	−0.02	2	− 0.8	1.5
12	12.46620	Paris	+1.19	0.5	− 2.4	0.5
13	13.42803	Paris (Méch.)	−2.67	0	− 4.5	0
14	13.43126	Paris	+0.03	1.5	+ 3.8	2
15	13.47739	Greenwich	+0.30	2	− 5.3	1.5
16	14.42702	Chislehurst	+1.07	0	+69.2	0
17	14.44072	Paris	+0.54	2	+ 2.0	2
18	16.44807	Paris	+0.55	2	− 5.2	1
19	18.39879	Paris	−1.10	1.5	− 9.5	2
20	19.39566	Greenwich	−0.74	4	+ 9.7	3
21	19.39741	Paris	+0.29	2	+ 0.9	3
22	19.43138	Chislehurst	+0.47	0	+34.7	0
23	20.40031	Chislehurst	—	—	+11.4	0.5
24	20.40295	Chislehurst	−1.83	0.5	—	—
25	20.43598	Greenwich	−1.56	3	−20.2	3
26	21.38603	Paris	−0.57	1.5	− 3.2	2
27	21.40475	Paris (Méch.)	−3.40	0	+27.6	0
28	22.38295	Greenwich	−0.95	4	+ 4.1	3
29	22.38766	Chislehurst	—	—	+ 3.4	0.5
30	22.39423	Chislehurst	+0.44	1	—	—
31	22.39660	Paris	−4.04	1.5	+13.8	1
32	23.40241	Chislehurst	−2.51	0	+32.0	0
33	23.40353	Greenwich	−4.00	1	− 3.0	0.5
34	23.42733	Paris	−4.53	1.5	− 5.8	2
35	24.37684	Milan (C.)	−8.59	0	+ 4.9	1
36	24.39629	Paris	−0.87	2	−11.5	2
37	24.39648	Chislehurst	−3.07	0	−19.7	9.5

No.	Berlin Mean Time	Place	Δα cos δ (O − C)	pα	Δδ O − C	pδ
			s		''	
38	Aug. 25.32785	Milan (C.)	−2.16	0.5	−22.4	1
39	25.37693	Greenwich	−0.96	4	+ 4.5	3
40	25.38442	Paris	−1.32	2	− 2.7	2
41	25.41565	Chislehurst	+0.47	0.5	−10.4	0.5
42	27.36003	Milan (R.)	+1.38	0	+ 4.1	0.5
43	27.38334	Paris	−0.70	2	− 1.0	3
44	27.40249	Milan (C.)	−3.14	0	+ 1.6	1
45	28.39120	Paris	−0.84	1.5	——	—
46	28.40021	Paris	——	—	−10.8	2
47	29.37882	Greenwich	−1.27	3	− 7.9	2
48	29.38882	Paris	−0.71	1.5	−12.0	2
49	29.39494	Chislehurst	−2.03	0.5	——	—
50	30.33745	Chislehurst	−1.77	0.5	——	—
51	30.34404	Chislehurst	——	—	+ 0.5	0.5
52	30.34763	Milan (R.)	−1.16	1	+ 9.6	0.5
53	30.36724	Paris	−0.37	1.5	−15.1	2
54	30.36789	Milan (C.)	−1.41	1	+ 6.1	1
55	30.37553	Greenwich	−0.77	4	− 2.1	3
56	31.32757	Milan (C.)	−1.35	1	− 0.2	1
57	31.34350	Milan (R.)	−1.54	1	+ 8.8	0.5
58	31.37020	Greenwich	−0.86	4	− 1.9	3
59	31.39008	Chislehurst	−9.57	1	——	—
60	31.39224	Chislehurst	——	—	−14.2	0.2
61	31.39610	Paris	−2.58	0	+ 6.0	1.5
62	31.40775	Paris (MÉCH.)	+0.18	0	− 23.8	0
63	Sept. 1.32796	Milan (C.)	−2.01	1	− 11.8	1
64	1.33565	Milan (R.)	−0.13	1	− 14.3	0.5
65	1.38681	Paris	−0.35	1.5	− 0.2	2
66	1.41132	Chislehurst	——	—	+ 11.9	0.2
67	1.41791	Chislehurst	+0.60	0	——	—
68	2.33246	Milan (C.)	−2.21	0.5	− 10.3	1
69	2.35373	Milan (R.)	−1.02	1	+ 34.9	0
70	2.39205	Greenwich	−1.13	3	− 2.5	2
71	2.40907	Chislehurst	−1.41	1	+ 37.1	0
72	4.34018	Milan (R.)	−1.74	1	− 32.2	0
73	4.35073	Milan (C.)	−2.00	1	− 25.2	1
74	4.36664	Greenwich	−0.80	4	− 6.9	3
75	4.37128	Paris	−0.13	2	− 1.6	3
76	5.36729	Greenwich	−1.19	4	− 12.2	3
77	5.40303	Paris	+0.31	2	+ 3.5	2
78	6.34112	Milan (C.)	−2.70	0.5	− 4.2	1
79	6.35175	Milan (R.)	−0.64	1	+ 28.5	0
80	6.35862	Paris	−0.54	2	+ 9.5	3
81	6.36374	Greenwich	−1.38	4	− 11.2	3
82	7.35100	Milan (C.)	−1.93	1	+ 19.5	0
83	7.38072	Paris	+0.11	2	+ 5.1	3
84	8.34158	Milan (C.)	−2.08	1	+ 18.5	0
85	8.35937	Milan(R.)	+0.15	1	+ 6.3	0.5
86	9.36070	Greenwich	−0.97	4	+ 5.8	3
87	9.36309	Paris (MÉCH.)	+5.52	0	− 1.7	0

No.	Berl. Mean Time	Place	$\Delta\alpha \cos \delta$ (O − C)	p^α	$\Delta\delta$ (O − C)	p^δ
			s			
88	Sept. 9.39741	Paris	−0.53	2	− 5.6	3
89	10.35919	Paris	+0.31	2	+ 0.9	3
90	10.36302	Greenwich	−1.46	2	− 7.3	1.5
91	11.34525	Milan (C.)	−1.66	1	− 5.2	1
92	11.36330	Paris	+0.78	1	− 4.2	3
93	11.36825	Milan (R.)	−0.99	0	+112.8	0
94	11.40023	Greenwich	−0.95	3	− 19.0	2
95	12.34034	Milan (C.)	1.53	1	− 11.2	1
96	14.36192	Greenwich	−0.60	4	− 8.5	3
97	15.34317	Greenwich	−0.74	3	+ 2.7	2
98	15.37738	Milan (C.)	−2.75	0.5	−102.7	0
99	16.35840	Saron	−0.80	1.5	− 0.4	2
100	17.34300	Milan (C.)	−2.74	0.5	− 2.7	1.
101	17.36724	Milan (R.)	−1.84	1	+ 10.2	0.5
102	17.43105	Greenwich	−0.93	0.5	+ 2.6	2
103	18.36221	Milan (C.)	−1.99	1	− 6.0	1
104	18.36244	Greenwich	−0.73	3	+ 0.3	2
105	18.37808	Milan (R.)	−2.81	0	+ 31.2	0
106	19.34159	Milan (C.)	−2.48	1	− 9.5	1
107	19.35015	Greenwich	−0.87	1	+ 3.7	3
108	19.35226	Milan (R.)	−0.95	1	+ 65.4	0
109	19.38984	Paris (Méch.)	+1.88	0	− 22.1	0
110	19.39584	Saron	−1.81	2	− 16.8	2
111	20.36440	Saron	−0.74	1.5	− 12.3	1.5
112	21.34712	Greenwich	−1.50	4	− 14.3	3
113	21.35862	Saron	−0.94	2	− 7.9	3
114	21.36029	Milan (C.)	−1.81	1	− 17.0	1
115	21.36365	Milan (R.)	−1.67	1	− 1.0	0.5
116	21.38846	Chislehurst	−14.	0	+ 61.	0
117	22.33393	Saron	+0.40	1.5	− 2.8	2
118	22.33593	Milan (C.)	−0.73	1	+ 5.7	1
119	22.34387	Milan (R.)	−0.28	1	+ 21.3	0
120	22.33312	Greenwich	−0.26	4	− 3.5	3
121	23.33720	Saron	+0.06	1.5	+ 1.0	2
122	26.38754	Greenwich	−0.10	4	− 9.2	3
123	27.32056	Milan (C.)	+10.40	0	− 9.7	1
124	29.31416	Milan (C.)	+0.27	0.5	− 53.3	0
125	29.32569	Milan (R.)	−10.40	0	+ 32.7	0
126	29.35154	Saron	−1.98	1	——	—
127	29.35775	Saron	——	—	− 26.8	2
128	30.35977	Saron	−0.01	1.5	− 7.4	2
129	Oct. 1.31452	Milan (C.)	+51.50	0	+ 3.1	0.5
130	1.35418	Saron	−1.16	0	− 2.2	2
131	3.34421	Saron	−5.08	0	− 10.2	0.5
132	5.32632	Saron	−0.21	2	+ 15.2	0.5
133	11.34352	Saron	+0.76	1	+ 4.4	1.5
134	13.32043	Paris (Méch.)	+4.16	0	− 25.4	0
135	13.33878	Saron	−2.31	0.5	− 14.1	1.5
136	13.35352	Milan (C.)	−8.10	0	− 33.3	0
137	14.31831	Saron	−0.63	2	+ 4.5	2

No.	Berlin Mean Time	Place	Δα cos δ (O — C)	pα	Δδ (O — C)	pδ
			s			
138	Oct. 14.32451	Milan (C.)	+117.–	0	– 39.8	0
139	14.33210	Greenwich	–0.43	3	– 25.8	2
140	16.30316	Saron	–0.01	0.5	+ 11.4	0.5
141	17.33647	Greenwich	+0.61	4	– 7.1	3
142	18.31163	Milan (C.)	+0.04	1	– 20.6	1
143	18.35133	Greenwich	+1.35	4	+ 3.0	3
144	18.35672	Paris(Méch.)	+4.83	0	– 17.1	0
145	19.29916	Milan (C.)	–2.48	0	+ 7.4	1
146	20.29741	Saron	———	——	+ 3.4	1.5
147	20.30696	Saron	+0.92	0.5	———	——
148	23.32173	Saron	–1.84	0.5	– 31.7	0
149	23.34495	Paris (Méch.)	+6.29	0	+ 27.3	0
150	25.33882	Greenwich	+0.77	3	– 2.2	2
151	26.29685	Saron	+2.84	1	– 22.4	0
152	26.33608	Greenwich	+1.63	4	– 3.2	3

Ephemeris places for the normal dates were computed with logarithms of seven decimal figures, and to these were applied the weighted means of the values O—C deduced from the preceding to form the normal places.

This comet passed *Mercury* at a distance of about 17.4 millions of miles, July 18. The perturbations due to this planet, though small, were, therefore, computed. As the comet approached *Venus* within 24.2 millions of miles, August 18, the influence of that planet was carefully considered. The perturbations due to the *Earth* and *Jupiter* were also computed. The components of the disturbing forces were computed for every tenth day, then interpolated for five day intervals, except in a few cases near the osculation epoch, when they were computed directly. By in-

No.	1786	Ephemeris Place		O — C			Normal Place	
		α	δ	Δα	Δα cos δ	Δδ	α	δ
		° ′ ″	° ′ ″	″	″	″	° ′ ″	° ′ ″
I	Aug. 10.5	189 19 35.8	+28 57 42.4	+ 1.3	+ 1.1	–0.4	189 19 37.1	+28 57 12.0
II	22.5	207 26 23.8	29 11 12.8	–15.9	–13.9	–2.7	207 26 7.9	29 11 10.1
III	30.5	217 30 23.0	28 16 56.4	–16.8	–14.8	–3.8	217 30 6.2	28 16 52.6
IV	Sept. 7.5	226 11 35.8	26 57 59.3	–14.2	–12.7	–3.6	226 11 21.6	26 57 55.7
V	19.5	237 10 53.4	24 43 0.0	–15.3	–13.9	–4.2	237 10 38.1	24 42 55.8
VI	Oct. 1.5	246 22 23.4	22 31 22.4	– 6.6	– 6.1	–8.3	246 22 16.8	22 31 14.1
VII	20.0	258 11 33.9	19 42 17.8	+12.6	+11.9	–3.7	258 11 46.5	19 42 14.1

No.	1786	Perturbation			O — C corrected for perturbations			Σp		Wt.	
		Δα	Δα cos δ	Δδ	Δα	Δα cos δ	Δδ	α	δ		
		″	″	″	″	″	″				
I	Aug. 10.5	– 0.2	–0.2	–0.3	+ 1.5	+ 1.3	–0.1	26	19.2	2	2
II	22.5	–0.5	–0.5	–0.5	–15.4	–13.4	–2.2	30.5	30.5	3	3
III	30.5	–0.7	–0.6	–0.6	–16.1	–14.2	–3.2	32.5	30.4	3	3
IV	Sept. 7.5	–1.0	–0.9	–0.6	–13.2	–11.8	–3.0	42.5	40.0	4	4
V	19.5	–1.3	–1.2	–0.7	–13.9	–12.7	–3.5	41.5	36.5	4	4
VI	Oct. 1.5	–1.6	–1.5	–0.7	– 5.0	– 4.6	–7.6	10.5	14.5	1	1
VII	20.0	–1.9	–1.8	–0.9	+14.6	+13.7	–2.8	23.5	19	2	2

tegrating, there were found the perturbations of the ecliptical coordinates, for which the osculation epoch is July 11.0. The resulting perturbations in right ascension and declination for the seven normal dates with the values of the residuals used in forming each normal place, and the final weight assigned to each normal place in the Least Squares solution, are as given above:—

Differential coefficients for the equations of condition were computed by the modified form of the Schonfeld formulae given by BAUSCHINGER (p. 460). These computations were done in duplicate and, as a further check, geocentric places were also computed from elements affected by increments of 100″ each. The relation of dP, dQ, and dS to the corrections of i, ω, and Ω is defined by the equations (BAUSCHINGER p. 435):—

$$
\begin{aligned}
dP &= \sin i \sin \omega \, d\Omega + \cos \omega \, di \\
dQ &= \sin i \cos \omega \, d\Omega - \sin \omega \, di \\
dS &= \cos i \, d\Omega + d\omega .
\end{aligned}
$$

The unweighted equations of condition, for which the unit is the second of arc, the coefficients and absolute terms being expressed logarithmically, are as follows:—

RIGHT ASCENSION.

9.43966dS	+9.53339*n*dP	+8.53294*n*dQ	+3.55750*n*dT	+9.84470$n\frac{dq}{\sin 1''}$	+9.63409$\frac{de}{2 \sin 1''}$	= 0.11394
9.62014	9.58022*n*	9.03948*n*	3.17962*n*	9.99434*n*	9.56441	1.12710*n*
9.70281	9.57309*n*	9.15695*n*	3.41918*n*	0.04239*n*	9.42824	1.15229*n*
9.76193	9.51834*n*	9.21553*n*	3.35546*n*	0.06746*n*	9.16901	1.07188*n*
9.82066	9.49099*n*	9.24511*n*	3.25805*n*	0.07982*n*	8.66921*n*	1.10380*n*
9.85678	9.41840*n*	9.23465*n*	3.16164*n*	0.07555*n*	9.37792*n*	0.66276*n*
9.88771	9.28559*n*	9.17138*n*	3.01760*n*	0.05374*n*	9.71111*n*	1.13672

DECLINATION.

9.71348dS	−9.71793dP	+8.71748dQ	+3.35701*n*dT	+0.07877$n\frac{dq}{\sin 1''}$	+9.03410$n\frac{de}{2 \sin 1''}$	= 9.00000*n*
9.70915	9.79310	9.25236	3.18048*n*	0.02119*n*	9.33770*n*	0.34242*n*
9.67955	9.82228	9.40614	3.06184*n*	9.96146*n*	9.40221*n*	0.50515*n*
9.63623	9.83871	9.50590	2.95828*n*	9.89259*n*	9.40846*n*	0.47712*n*
9.55156	9.84641	9.60053	2.82019*n*	9.78157*n*	9.33887*n*	0.54407*n*
9.46022	9.84130	9.65755	2.70727*n*	9.66782*n*	9.17725*n*	0.88081*n*
9.29878	9.82091	9.70670	2.57007*n*	9.49398*n*	8.44738*n*	0.44716*n*

These equations multiplied by the square roots of the weights previously assigned and rendered homogeneous by the introduction of the quantities

$x = 0.12169 \, dS$ $\qquad t = 3.71818 \, dT$

$y = 0.14744 \, dP$ $\qquad u = 0.38085 \frac{dq}{\sin 1''}$

$z = 9.90156 \, dQ$ $\qquad v = 9.86162 \frac{de}{2 \sin 1''}$

unit of error 1.40483

led to the following equations of condition:—

9.46848x	+9.53646*n*y	+8.78189*n*z	+9.98983*n*t	+9.61436*n*u	+9.92298v	= 8.85962
9.73701	9.67134*n*	9.37648*n*	0.00000*n*	9.85205*n*	9.94135	9.96083*n*
9.84968	9.66421*n*	9.49395*n*	9.93956*n*	9.90010*n*	9.80518	9.98602*n*
9.94127	9.70193*n*	9.61500*n*	9.93831*n*	9.98764*n*	9.60842	9.96808*n*
0.00000	9.61158*n*	9.64158*n*	9.84099*n*	0.00000*n*	9.10862*n*	0.00000*n*
9.73509	9.27096*n*	9.33309*n*	9.14346*n*	9.69470*n*	9.51630*n*	9.25793*n*
9.91653	9.28866*n*	9.42033*n*	9.41993*n*	9.82340*n*	0.00000*n*	9.88240
9.74230	9.72100	8.96643	9.78934*n*	9.84843*n*	9.32299*n*	7.74568*n*
9.82602	9.88122	9.58936	9.70086*n*	9.87920*n*	9.71464*n*	9.17615*n*
9.79642	9.91340	9.71314	9.58522*n*	9.81917*n*	9.77915*n*	9.33888*n*
9.81557	9.99230	9.90537	9.51113*n*	9.81277*n*	9.84787*n*	9.37332*n*
9.73390	0.00000	0.00000	9.40304*n*	9.70175*n*	9.77828*n*	9.44027*n*
9.33853	9.69386	9.75599	8.98909*n*	9.28697*n*	9.31563*n*	9.47598*n*
9.32760	9.82398	9.95565	9.00240*n*	9.26361*n*	8.73627*n*	9.19284*n*

From these equations there were obtained the following:—

NORMAL EQUATIONS (coefficients natural numbers)

$$\begin{array}{rrrrrrcr}
+5.5190x & +0.9458y & +0.5533z & -4.5666t & -5.7895u & -1.3150v & = & -3.0396 \\
+0.9458 & +5.2604 & +1.2433 & +0.3221 & -0.8566 & -3.3159 & & +0.5890 \\
+0.5533 & +4.2433 & +3.8901 & +0.2216 & -0.4607 & -2.1218 & & +0.2206 \\
-4.5666 & +0.3225 & +0.2216 & +5.0850 & +5.1250 & -1.9938 & & +3.3797 \\
-5.7895 & -0.8566 & -0.4607 & +5.1250 & +6.1918 & +0.8366 & & +3.5143 \\
-1.3150 & -3.3159 & -2.1218 & -1.0938 & +0.8366 & +4.7381 & & -1.6954
\end{array}$$

ELIMINATION EQUATIONS (coefficients natural numbers)

$$\begin{array}{rrrrrrcr}
+5.5190x & +0.9458y & +0.5533z & -4.5666t & -5.7895u & -1.3150v & = & -3.9396 \\
 & 5.0893 & +4.1485 & +1.1051 & +0.1355 & -3.0905 & & +1.1099 \\
 & & 0.4599 & -0.2198 & +0.0094 & +0.5247 & & -0.3778 \\
 & & & 0.9617 & +0.3098 & -1.2607 & & +0.4432 \\
 & & & & 0.0148 & -0.0654 & & +0.1612 \\
 & & & & & 0.0100 & & -0.0215
\end{array}$$

An examination of the differential coefficients had already disclosed the fact that the eccentricity could not be determined with any degree of certainty and the coefficient of v in the last elimination equation confirms that conclusion. As the coefficient of u also is small, the first four unknowns were expressed in terms of u and v and then in terms of v by the method given by OPPOLZER (Bd. II, p. 362 foll.).

$$\begin{aligned}
x &= -0.21322 + 0.76820u + 1.24754v \\
&= +8.0464 + 4.6195v \\
y &= +0.69797 + 0.18543u + 0.74141v \\
&= +2.6017 + 1.5554v \\
z &= -0.60241 - 0.17474u - 0.51538v \\
&= -2.4812 - 1.2824v \\
t &= +0.46085 - 0.32214u + 1.31091v \\
&= -3.0028 - 0.1032v \\
u &= +10.7520 + 4.3896v
\end{aligned}$$

were the values substituted and this solution gave the following:—

$$\begin{array}{lll}
ds = -87''.054 \pm 184''.19 & & Q_{11}\ [3.34157] \\
dP = -29\ .563 \pm 58.34 & & Q_{22}\ [2.39453] \\
dQ = +32\ .231 \pm 85.16 & & Q_{33}\ [2.23122] \\
dT = -0^{d}.013228 \pm 0^{d}.003038 & & Q_{44}\ [0.96920] \\
dq = -0.0000617 \pm 0.0004716 & & Q_{55}\ [3.30542] \\
de = -0.0009225 \pm 0.0006937 & & Q_{66}\ [2.00000]
\end{array}$$

Q_{11}, Q_{22} etc., the logarithms of the reciprocals of the weights, were determined by the usual method (BAUSCHINGER, pp. 413-415).

This solution reduced the sum of the squares of the residuals from 2949″.3 to 215″.8. The probable error of a normal place of weight unity is ±3″.50.

In order to discover the effect upon the elements of varying the eccentricity, various values were arbitrarily assigned to *de* and the resulting values of dT, etc., substituted in the equations of condition. The sums of the squares of the resulting residuals are given below, *de* being expressed in units of the third decimal place:—

Solution		(II)	(V)	(I)	(VI)	(IV)	(III)
de		−1.845	−1.616	−0.9225	−0.2288	0	+0.9225
Σ pvv	$\Delta\alpha \cos\delta$	″ 104.727	90.610	83.045	126.705	153.055	322.389
	$\Delta\delta$	159.124	151.989	132.782	115.304	112.099	89.355
Sum		263.851	242.599	215.827	242.099	265.154	411.744

The fact that the value of *de* determined by the solution produces the smallest Σ*pvv*, 215″.8, a quantity satisfactorily small for a comet of that period, would seem to confirm the results of the solution. Further inspection of this table, however, shows that, whereas the observations in right ascension are best represented by an ellipse of the determined eccentricity or somewhat larger, the declination residuals are reduced in amount by smaller values of *de*, being least in the case of a slightly hyperbolic orbit. This marked characteristic of the residuals, in connection with the inherent probability of less accuracy in the observations in declination than in right ascension which had received confirmation from the rough probable errors of observation already deduced for each observer, led to further investigation.

The increments ds, dr, dq, etc., corresponding to the above values of de (exclusive of the positive value) were determined and di, $d\omega$, and $d\Omega$ from ds, dr, and dq. These corrections were then applied to the provisional elements, forming five systems of elements. Owing to the much greater value of Σpvv for the hyperbolic elements and the fact that a positive de lies beyond the limit of probable error, the hyperbolic elements were entirely omitted from the discussion.

With each of the remaining five systems of elements the positions for the seven normal dates were computed and compared with the normal places corrected for perturbations. The residuals thus found, together with those obtained from the equations of condition are given in the following:

Differences (C − O)

Normal Pl. No.	$\Delta\alpha\cos\delta$ From Elements (II)	$\Delta\alpha\cos\delta$ From Equations	$\Delta\delta$ From Elements (II)	$\Delta\delta$ From Equations	$\Delta\alpha\cos\delta$ From Elements (V)	$\Delta\alpha\cos\delta$ From Equations	$\Delta\delta$ From Elements (V)	$\Delta\delta$ From Equations
I	+2.2	+2.2	+3.7	+3.5	+1.8	+1.8	+3.3	+3.3
II	−1.3	−1.3	+0.0	+0.7	−1.3	−3.9	+0.4	+0.8
III	−1.3	−1.1	−1.2	−1.2	−1.0	−0.8	−1.6	−1.2
IV	+2.5	+2.9	−2.0	−1.7	+2.5	+2.8	−2.0	−1.7
V	−0.6	−0.1	−2.2	−1.8	−1.5	−0.9	−2.0	−1.8
VI	−0.2	+0.3	−4.0	−3.7	−0.1	−0.1	−3.9	−3.7
VII	+0.0	+0.6	+6.5	+6.8	+0.8	+1.2	+6.5	+6.6
	From Elements (I)	From Equations	From Elements (I)	From Equations	From Elements (VI)	From Equations	From Elements (VI)	From Equations
I	+0.6	+0.6	+3.0	+3.0	−0.6	−0.6	+3.3	+2.7
II	−2.4	−2.4	+0.3	+0.8	−1.4	−0.9	+0.6	+0.9
III	−0.2	+0.0	−1.2	−1.2	+0.1	−0.3	−1.2	−1.1
IV	+2.6	+2.6	−1.6	−1.6	+1.9	+2.3	−1.6	−1.5
V	−2.3	−2.3	−1.8	−1.6	−4.0	−3.6	−1.5	−1.4
VI	−1.3	−1.3	−3.6	−3.6	−2.8	−2.4	−3.2	−3.5
VII	+2.9	+2.9	+6.2	+6.1	+3.9	+4.6	+5.8	+5.7
	From Elements (IV)	From Equations	From Elements (IV)	From Equations				
I	−1.3	−1.3	+2.7	+2.6				
II	−0.4	−0.1	+0.9	+1.0				
III	+1.1	+1.2	−1.1	−1.1				
IV	+2.1	+2.3	−1.5	−1.5				
V	−3.9	−1.1	−1.5	−1.3				
VI	−2.9	−2.9	−3.4	−3.4				
VII	+5.0	+4.9	+5.7	+5.6				

An inspection of these results leads to the conclusion that, although a slightly elliptical orbit best satisfies the observations, the best parabolic elements do no violence to the normal places. Since all of these systems of elements satisfy the equations so well, they are inserted below:

	Elements (II)	Elements (V)	Elements (I)	Elements (VI)	Elements (IV)
T	1786, July 7.91996	1786, July 7.91961	1786, July 7.91859	1786, July 7.91756	1786, July 7.91691
	° ′ ″	° ′ ″	° ′ ″	° ′ ″	° ′ ″
1786.0 ω	− 35 7 52.02	− 35 6 24.80	− 35 2 0.77	− 34 57 36.66	− 34 56 5.45
☊	194 30 5.43	194 29 22.21	194 27 11.37	194 25 0.47	194 24 15.59
i	50 55 7.03	50 55 6.77	50 55 5.97	50 55 5.17	50 55 4.88
log q	9.6122281	9.6123895	9.6128774	9.6133649	9.6135373
log e	9.9991980	9.9992976	9.9995992	9.9999006	
Period	3306.3 years	4035.7 years	9372.7 years	76008 years	

From this investigation it would appear, therefore, that, owing to the inaccuracy of the observations of that period and the resulting uncertainty of the normal places, it is impossible to determine the nature of the orbit with certainty. The orbit (I), obtained by the solution is slightly elliptical, requiring about 9,000 years, for one revolution. In so far, however, as this computation shows, either a much smaller ellipse (II), requiring about 3,300 years for one revolution, or a parabola (IV) would satisfy the equations of condition within the limits of accuracy of the observations.

Yale Observatory, August 2, 1918.

DIRECT MICROMETRICAL OBSERVATIONS OF THE *SUN*,

THE ECLIPSE OF JUNE 8, 1918,

By E. D. ROE, Jr.

In order to observe the *Sun* with the micrometer directly, I diaphragm the 6½-in. Clark refractor down to 1 5/16 in. so that the intensity on the threads is slightly above that of normal sunlight. I use a tinted cover glass over the eyepiece, which gives a power of 100. A large pasteboard shield is also attached to the objective cell to cut off the *Sun's* rays from every part of the tube and vicinity of the eye end. This method of observing the *Sun* is very satisfactory. The definition is sufficiently good to measure the diameter of sunspots and to show faculæ. On the 5th of June I measured the diameter of one of a pair of spots and got 22,918 miles for the subtending line perpendicular to the line of sight. The same pair was still on during the eclipse.

This method can be applied to any telescope. It is only necessary to use a diaphragm slightly exceeding the diameter of the focal image of the *Sun* for the given telescope. Thus in 1915 I observed the *Sun* with the 12.2-in. refractor of the Yerkes Observatory with a 2-in. diaphragm and obtained satisfactory measurements of sunspots.

In order to observe the point of first contact in the recent eclipse I set and clamped the threads (in coincidence) perpendicular to the position angle 258°, calculated for Syracuse by the Naval Observatory, (that is, at 168°). With driving clock on, the *Sun's* disc was by means of the slow motions brought up to tangency with the thread. The point of tangency was then at position angle 258°. I had to watch only this single point. The limb of the *Sun* showed a delicate boiling motion or was like a distant field of waving grass. My chronograph watch was set at the noon signal (60th meridian time) to a second in agreement. The first contact was calculated by the Naval Observatory to occur at Syracuse at $10^h\,28^m$ G. M. T. to the nearest minute. At $10^h\,26^m$ I started the second hand and watched. Suddenly the boiling or waving grass motion subsided as if something pressed down on it. I touched the stem. I could not see that the position angle could be improved nor a moment later when the thread became the common chord of intersection by a slight shift. The second hand registered $2^m\,9^s$, making the contact then recorded at $10^h\,28^m\,9^s$. On account of trees in the street, it was not possible to observe the second contact from the observatory. The 2½-in. Clark refractor (equatorial tripod mounting) was carried to a nearby eminence from which an unobstructed view of the western horizon was secured. With the full aperture, a sun diagonal and a power of 37½ could be seen all details of sunspots, pores, granular structure and faculæ. The end was calculated at $12^h\,14^m$. At $12^h\,10^m$ I started the second hand. A cloud interfered and then passed off. At $12^h\,13^m\,4^s$ very close to second contact a second cloud shut out the view. The contact could have been only a few seconds later. Next day at the noon signal the watch was eleven seconds slow. It had probably lost about one-half second an hour.

Thus the most probable corrected time for the two contacts was, at Syracuse, from my observations, $10^h\,28^m\,12^s$ and $12^h\,13^m\,8^s$ + G. M. T.

Roe Observatory, 25 June, 1918.

A DETERMINATION OF THE CONSTANT AND PROBABLE ERRORS OF THE *GREENWICH ASTROGRAPHIC CATALOG*,

By J. G. PORTER

The *Greenwich Astrographic Catalog*, +64° to +90°, is, as far as I know, the only one which has been published in completed form.

For the 278 stars common to this catalog and the *Cincinnati Proper-Motion Catalog* (Publication No. 18, Part IV) the Greenwich positions were reduced to 1900 by the Cincinnati proper-motions, and the differences from the Cincinnati catalog tabulated. The average differences, in the sense Ci. — Green., are $\Delta\alpha \cos\delta = -0^s.016$, $\Delta\delta = +0''.10$. After these constants were applied the differences were again formed and the probable errors computed, which come as follows:

P. E. $\alpha \cos\delta = \pm 0^s.019 = \pm 0''.28$, P. E. $\delta = \pm 0''.28$.

We have next to determine what part of this error is due to the Cincinnati positions. All of these stars occur in Ci_1, and the probable error of one Cincinnati observation has been found (*Preface Publication* 18, Part IV) for $\alpha \cos\delta$ $\pm 0''.36$ and for δ $\pm 0''.37$. For the mean of four observations then we shall have $\pm 0''.18$ for each coördinate. Since the positions in the *Proper Motion Catalog* depend not only on Ci_4 but usually on two or three other modern catalogs, I have assumed the probable error to be not greater than $\pm 0''.15$ for each coördinate. This would leave for the probable error of the Greenwich positions $\pm 0''.24$.

The *Cincinnati Proper-Motion Catalog* does not include any of the stars contained in Boss' *Preliminary General Catalog*. I have therefore made a similar comparison between the *Greenwich Astrographic Catalog* and Boss. Since the Cincinnati catalog contains only one star above 80° declination, I have omitted the stars in Boss' above 81°. This left 272 stars. Proceeding in the same manner as before, the constant differences Boss — Greenwich were found to be for $\alpha \cos\delta$ $-0^s.024$ and for δ $+0''.15$. These are nearly the same as were found in the case of the former comparison, and show that for this part of the sky the system of the *Cincinnati Proper-Motion Catalog* is practically identical with that of Boss. This was to be expected, since the difference between the system of AUWERS, used in the Cincinnati catalog, and the system of Boss is insignificant. (See *Astronomical Journal*, No. 615.)

The probable errors computed from the corrected residuals, Boss — Greenwich, are for $\alpha \cos\delta$ $\pm 0''.28$ and for δ $\pm 0''.29$. The average probable error of the Boss positions may be inferred from the values given in the catalog itself for the mean epoch and for 1910, and are not far from $\pm 0''.15$ in each coördinate. We therefore obtain for the probable error of the Greenwich positions $\pm 0''.24$ for both $\alpha \cos\delta$ and δ — the same as from the comparison with the Cincinnati catalog.

The probable errors of the Greenwich results as given in the preface to the catalog are $\pm 0''.16$ for stars between the pole and 72°, and $\pm 0''.18$ for stars between 72° and 65°. We may remark, however, that the probable errors found by comparison of the individual results, whether obtained by the meridian circle or by the measuring engine, will naturally be smaller than those given by comparison with positions resulting from independent determinations by different instruments and different observers.

The result of this investigation then is to show that the probable error of the stellar coördinates as determined by the measurement of two astrographic plates is not far from a quarter of a second, or practically the same as that of the mean of two observations with the Cincinnati meridian circle. The larger and finer meridian instruments give somewhat better results. Indeed, the best instruments located where the definition is uniformly good would doubtless give a probable error as low as a quarter of a second for a single observation.

While it cannot be said that the photographic method is more accurate than the visual, yet the showing for the Greenwich catalog must be regarded as eminently satisfactory, especially when we consider the fact that the accuracy of the measures of the fainter stars is likely to be somewhat greater than those of the brighter stars.

Cincinnati Observatory, Nov. 2, 1918.

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